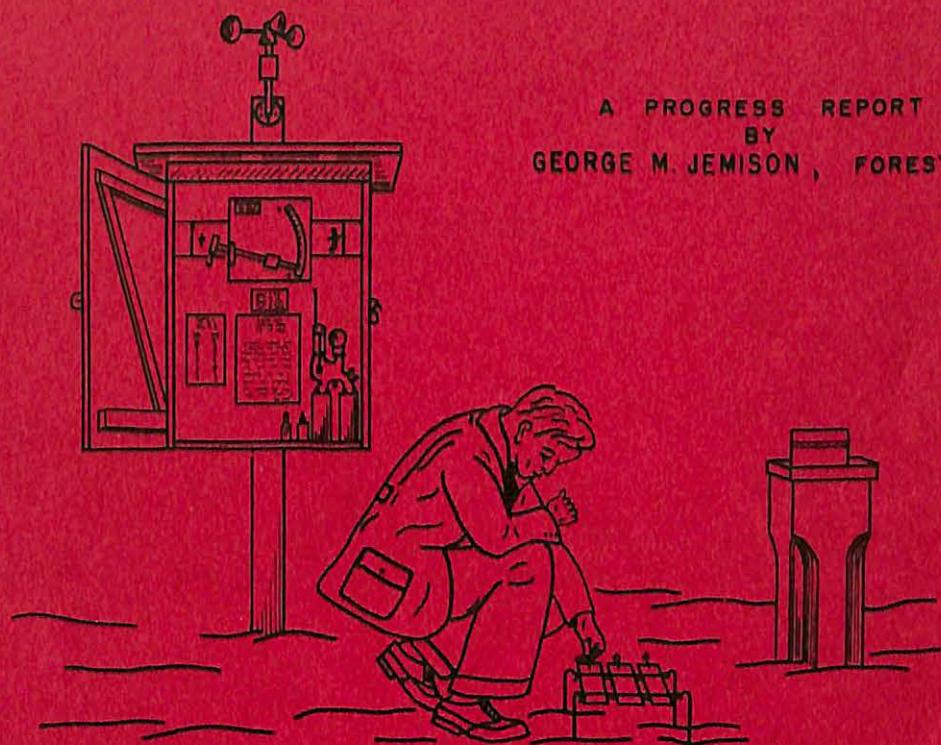


THE MEASUREMENT OF FOREST FIRE DANGER  
IN THE EASTERN UNITED STATES AND ITS  
APPLICATION IN FIRE PREVENTION AND CONTROL

A PROGRESS REPORT  
BY  
GEORGE M. JEMISON, FORESTER



U. S. DEPARTMENT OF AGRICULTURE  
FOREST SERVICE  
APPALACHIAN FOREST EXPERIMENT STATION  
ASHEVILLE, NORTH CAROLINA

TECHNICAL NOTE No. 50

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JANUARY 1, 1942

## FOREWORD

In the two years since our first progress report on forest fire danger measurement was issued as Technical Note 35, the danger rating system has been tested extensively throughout many parts of the East and South by 13 state fire organizations, by 19 national forests, by 23 national parks, monuments, or recreation areas, by the Indian Service, the Tennessee Valley Authority, and by 5 private forestry organizations. These tests and additional research by the Station have enabled us to make certain adjustments and improvements in the original system.

The following statement, a second progress report, has been prepared as was the first, to supply detailed information on fire danger rating -- what it is, how it may be used, where instruments may be purchased, how danger stations should be installed and operated, etc. -- so that those agencies interested in using the danger rating system might have adequate information under one cover, something we can not supply in the regular channels of correspondence. While the methods suggested in this report represent the best procedures determined to date at the 264 stations now actively in operation, we continue to solicit constructive criticism because the danger rating system, described in these pages, is not necessarily in final form.

*R. E. McARDLE*

R. E. McARDLE  
Director

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THE MEASUREMENT OF FOREST FIRE DANGER IN THE EASTERN<sup>1/</sup>  
UNITED STATES AND ITS APPLICATION IN  
FIRE PREVENTION AND CONTROL

By

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Appalachian Forest Experiment Station, Asheville, N. C.

#### INTRODUCTION

This technical note<sup>2/</sup> describes a method of measuring forest fire danger<sup>2/</sup> and expressing it in numerical classes having definite meaning and calling for definite action. Heretofore it was possible to rate fire danger only in general terms such as "bad", "fairly bad", "not so bad", and the like, with--in too many instances--correspondingly uncertain and indefinite preparation for presuppression and suppression.

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1/For the purposes of this discussion, "Eastern United States" is considered to include New England, the Allegheny and Cumberland Plateaus and adjacent lowlands, the southern Appalachian Mountains and adjacent Piedmont and Coastal Plain. It does not include the deep South, Lake States, or Central States.

2/This technical note is a second progress report on fire danger measurement, the first report having been published as Technical Note 35 of this same series, in October 1939. The writer gratefully acknowledges assistance in revision of the earlier report given by R. M. Feaster, employed by Region 7 of the U. S. Forest Service.

3/As this technical note is addressed to technical fire control men, no attempt is made to define the numerous fire control terms used in it. The term "fire danger", however, is used narrowly and refers only to the variable aspects of fire danger such as weather elements and fuel moisture. For complete definitions of this and other terms the reader should refer to "Glossary of terms used in forest fire control", U. S. Dept. Agr., Forest Service, 1939.

The method here discussed is based on intensive study of the factors that influence the ease with which fires start and the rate at which they spread. More than 15 years ago, in the West, when investigations of fire danger were first begun, 10 or 15 elements were recognized as having an influence on fire danger. Since that time a number of workers have studied the many factors to find out exactly how important each actually is. As a result of recent investigations 4 key factors have been identified for eastern mountain forests and 3 for adjacent coastal plain types.

The former study confirmed a suspicion held by experienced fire control men that relatively small changes in certain factors influencing fire danger caused much larger changes in ease of ignition, rate of spread, and difficulty of control. These small changes defy any dependable estimate by guessing even if the guessing is done by men with considerable fire experience; such changes must be measured. Instruments had to be invented for the measurement of some factors; for others, existing instruments were too expensive for widescale practical use. Means were found to cheapen these instruments in price without reduction in accuracy.

After the discovery of the few key factors having most influence on the increase and decrease of fire danger, the next step was the development of a system for integrating these factors to obtain uniform results in measurements. To do this required careful, on-the-fire study of the conditions prevailing at the time of start of many hundreds of fires and the ease or difficulty of their control. This particular study is still in progress but enough information has been obtained to make possible a reasonably accurate weighting of each fire danger factor so that the most important ones exert the most influence on the final expression of fire danger. The device used to integrate all of the fire danger factors is called a "fire danger meter" and will later be described in detail.

Finally, it was necessary to test this method of rating fire danger over a large area. Preliminary tests have been made, beginning in 1937 and continuing without break on a steadily increasing scale to date. During the past year there have been about 260 stations in operation in 21 eastern and southern states in the forest types for which the system described here was prepared. Concurrent with the extensive field tests, experimental work has been continually under way at the Appalachian Forest Experiment Station and at a New Jersey branch of the Allegheny Forest Experiment Station cooperating on the project since 1939.

The system is not yet perfected and further improvement will undoubtedly be made as investigations continue. Although many changes have been made since the first report was issued in 1939,

the final pattern for fire danger rating is unchanged and appears to be reasonably well fixed. These and subsequent modifications probably will be only refinements to increase accuracy. In its present stage, the system is well advanced and can be offered to fire control executives for still more extended use.

The busy fire control official will find the following advantages in this system of fire danger measurement:

It focuses attention on the really important factors influencing fire danger.

It insures that every observer will measure and report on these factors in exactly the same way, thus giving accurate and comparable results even when the fire control executive has to depend for information on men much less experienced than himself.

It points out the small changes in fire danger conditions which may greatly influence the difficulty of fire control.

It provides a means for integrating measurements of the critical fire danger factors into a single numerical class which can be translated into decisive presuppressive and suppressive action.

It aids, does not displace, judgment of experienced fire control executives.

## THE PRINCIPLES OF FOREST FIRE DANGER MEASUREMENT

### Fire Danger Factors, Their Measurement, and Integration

#### The "Key" Fire Danger Factors

Fuel Moisture Content. Moisture content of fuels, a controlling fire danger factor, is particularly important in light-weight material such as dead grass, hardwood leaves, weeds, and pine needles. Fire brands ignite this material first and it burns most rapidly.

The moisture content of these light-weight fuels changes rapidly as weather fluctuates, but the relation is so complex

that moistures can not easily or accurately be determined from measurement of atmospheric factors such as humidity, temperature, and evaporation. Experience has proved that even the most experienced men can not determine changes of a few percent in fuel moisture content which may make considerable difference in inflammability.

One simple and inexpensive way to measure fuel moisture is by means of fuel moisture indicator sticks. Different sizes, shapes, and kinds of indicators are used in the United States, but flat slats 18 inches long, made from basswood, Venetian blind stock, have been found to work best in the East. These sticks, when exposed under typical forest conditions, reveal the effect, in one simple measurement, of all controls (the causes) of moisture content, such as humidity, temperature, evaporation, solar radiation, and wind. The fuel moisture sticks do not always indicate the exact moisture content of natural fuel, but the relation between indicated and actual moisture is relatively constant. In general, the sticks dry out slightly faster than natural fuel after a rain and thus give some forewarning of approaching dangerous conditions.

The method of determining fuel moisture consists essentially of exposing under natural conditions a set of 3 numbered basswood sticks, for which the oven-dry weight has been predetermined, and weighing them currently on a specially constructed scale. This scale shows average moisture content directly.

While the wood sticks provide excellent measures of current changes in the light fuels they do not reflect the cumulative build up of inflammable conditions in heavier fuels, denser "rough", and deeper layers of hardwood leaves resulting from several days of dry weather. When these classes of fuel become dry, fires burn hotter, are harder to control, and require more mop-up work. But here, also, a means of appraising inflammability has been determined. It has been found that the number of days elapsed since rains of different amounts is a useful index of cumulative drying. Because of differences between mountain (hardwoods) and coastal plain (pine-woods) fuel types, this factor is of less importance in the coastal plain regions particularly in the winter and spring seasons.

Wind. Measurements of wind velocity are important, because wind velocity is difficult to estimate and is of first importance in affecting rate of spread if fuels are dry enough to burn. Measurements of velocity can be made with any one of a number of buzzer type anemometers. Because coastal plain fuels (principally dead grass) are finely divided and exposed to the air, wind velocity must be given more weight in the flatwoods than in mountain forests.

Condition of Vegetation. The state of the physiological activity of plants, varying with latitude, elevation and aspect, is another factor which contributes to the degree of fire danger. For example, grasses, weeds and shrubs tend to retard the rate of spread of fire as long as they are succulent and transpire large quantities of moisture; but when they are dry their effect on fire behavior is reversed. This difference in inflammability resulting from physiological condition is outstanding in the pine forests in the lower country where grass is a primary fuel. Transition periods, when vegetation is coming up in the spring or when it is curing in the fall, are intermediate in their effect on fire danger. In some sections of the East this transition is very gradual in the fall, in others it is very abrupt owing to sudden, heavy autumn frosts.

Season of the Year. The intensity of solar radiation obviously determines the drying rate of forest fuels, and since it varies with the calendar, the season of the year becomes an important fire danger factor. This is particularly true in mountainous or hilly country where the movement of the sun towards the zenith as spring and summer approach causes more rapid and complete drying on north slopes. In fall and winter north slopes often act as good fire breaks because sunlight reaches the ground for only a few hours each day or perhaps not at all. In the flat country such effects do not exist, of course, and season of the year is not as important as other variables.

Season of the year is also a direct measure of length of day. During summer months the days are long and with more hours of sunlight fuels tend towards low moisture levels for longer periods. In the summer, shade of a hardwood overstory somewhat reduces the effect of long days because dead ground fuels are not exposed to sunlight at all. Length of day is a factor during the leafless seasons, however. Long, cool, humid nights at this time of the year create more favorable conditions, of course, and the burning day is considerably shorter. This is particularly true at northern latitudes where the length of day may change 7 or 8 hours during the year. Even in the southernmost portion of the Appalachian region, length of day changes 4 to 5 hours from winter to summer.

Thus, the 4 key factors to be measured in this danger rating system are (1) fuel moisture determined from wood sticks and number of days since rain, (2) wind, (3) condition of vegetation, and (4) season of year.



#### Systematic Measurement of the Key Factors

Fire danger is ordinarily determined from measurements taken several times a day at a network of stations<sup>4/</sup> so located as to sample major variations in fire weather caused by topography and other physical features. A typical fire danger station consists of a fuel moisture scale housed in a weighing shelter, a set of indicator sticks, an anemometer, and a rain gauge (illustrated above).

Fire occurrence is also an important consideration in the location of stations; hence danger should be measured at points where fires normally occur with the greatest frequency.

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<sup>4/</sup>See pages 30 and 31 for complete description of selection of fire danger station locations.

Ordinarily, one station for every 150,000 acres of protected land in the mountains and one per 300,000 acres of land in level or rolling country is a suitable number with which to start. If this is insufficient, "holes" in the network will become evident and can be filled.

Three daily measurements of fuel moisture and wind, and of rain twice a day provide the data necessary to follow the development of critical conditions as well as to obtain an accurate average daily danger rating. Any towerman, guard, or C. C. C. enrollee can read the instruments and record the observations in about 5 minutes.<sup>5/</sup> Some agencies prefer to follow the changes in danger more closely and require observers to take as many as 6 readings a day during critical periods.

### Integration of Measurements

Current measurements of the key fire danger factors are integrated or woven together into numerical classes by means of 2 danger meters, one for the mountain region, the other for the coastal plain. These meters are simple cardboard "slide rules." The mountain type is illustrated on page 8.

The factors integrated into these current danger classes by the mountain meter are: (1) fuel moisture as indicated by wood sticks and days since latest rain, (2) wind velocity, (3) condition of lesser vegetation, and (4) season of year. The "season of year" factor is not of sufficient importance to require consideration on the coastal plain meter, and because of regional variations in climate, latitude, elevation, and forest types, the other factors are given different weights on the 2 meters.

Predictions of fire danger class for not more than a 24-hour advance period are desirable because of the characteristic rapid and frequent fluctuations in danger that make it difficult for fire control men to estimate class of danger for the future. The first models of the danger meters included a device for forecasting "tomorrow's" fire danger, essentially by modifying current danger on the basis of predicted state of weather and wind. Extensive tests have shown that this feature could be relied upon to forecast danger with a satisfactory degree of accuracy in most parts of the East, but unfortunately this required considerable local adjustment in the mountains. Because of this impracticability,

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<sup>5/</sup>Pages 34 to 41 explain procedure in detail.

the forecasting feature has been eliminated on the new mountain danger meter presented with this report. Fire danger may still be predicted by an experienced man, however, using this meter with a forecast of wind and weather, and estimating tomorrow's fuel moisture content from this information. The form of the coastal plain meter has not been changed.

## FOREST FIRE DANGER METER MOUNTAIN TYPE

### FOREST FIRE DANGER METER

FOR USE IN THE MOUNTAINOUS REGIONS OF THE  
EASTERN UNITED STATES

•••

#### SEASON OF YEAR

| AMOUNT<br>OF<br>LAST RAIN | MARCH 1<br>TO<br>APRIL 15   |        |                          | OCT. 16<br>TO<br>FEB. 28 |                          |            |
|---------------------------|-----------------------------|--------|--------------------------|--------------------------|--------------------------|------------|
|                           | APRIL 16<br>TO<br>AUGUST 31 | —<br>— | SEPT. 1<br>TO<br>OCT. 15 | —<br>—                   | OCT. 16<br>TO<br>FEB. 28 |            |
| 0.25" TO 0.50"            | 124                         | 6-9    | 2-4                      | 14+7-11                  | 3-5                      | 16+9-134-6 |
| 0.51" OR MORE             | 10+                         | 5-7    |                          | 12+6-9                   |                          | 14+7-11    |

#### CONDITION OF VEGETATION

| WIND VELOCITY<br>IN<br>MILES PER HOUR | FUEL MOISTURE CONTENT<br>IN PERCENT |                    |                    |                   |                  |                   |
|---------------------------------------|-------------------------------------|--------------------|--------------------|-------------------|------------------|-------------------|
|                                       | 25.1<br>OR<br>MORE                  | 18.6<br>TO<br>25.0 | 12.6<br>TO<br>18.5 | 7.6<br>TO<br>12.5 | 4.0<br>TO<br>7.5 | 3.9<br>OR<br>LESS |
| 0 TO 1.4                              | 1                                   | 1                  | 2                  | 3                 | 3                | 4                 |
| 1.5 TO 3.4                            | 1                                   | 1                  | 2                  | 3                 | 3                | 4                 |
| 3.6 TO 7.4                            | 1                                   | 2                  | 2                  | 3                 | 4                | 4                 |
| 7.5 TO 12.5                           | 1                                   | 2                  | 3                  | 4                 | 4                | 4                 |
| 12.6 TO 18.5                          | 1                                   | 2                  | 3                  | 4                 | 4                | 5                 |
| 18.6 OR MORE                          | 1                                   | 2                  | 3                  | 4                 | 5                | 5                 |

#### CLASS OF FIRE DANGER

(SEE INSTRUCTIONS ON REVERSE SIDE)

FRONT

#### INSTRUCTIONS

(1) Above upper window, select section that shows present season of year. Choose column in this section that indicates proper condition of vegetation shown below window as "G" (for green), "T" (for transition), and "C" (for cured).

(2) Move slide down until the correct number of days since rain in the column chosen above appears opposite the row on the left representing amount of last rain.

(3) Read fire danger class in the bottom window opposite measured wind velocity and in the column below fuel moisture content.

#### DANGER PREDICTION

This meter may be used to predict tomorrow's danger if (1) a weather forecast of state of weather and wind velocity is available and (2) fuel moisture content is estimated.



U. S. DEPARTMENT OF AGRICULTURE  
FOREST SERVICE  
APPALACHIAN FOREST EXPERIMENT STATION  
ASHEVILLE, NORTH CAROLINA  
METER TYPE 5-B

JANUARY 1, 1942

BACK

Actual operation of the danger meters is extremely simple and merely involves setting of one movable slide. When this slide is set according to directions on the back side of the meter, the danger class can be read for each combination of conditions.

Danger is rated on a numerical scale of 1 to 5, class 1 representing the lowest danger and class 5 the very greatest that can be experienced. The corresponding classes of the mountain and coastal plain meters are directly comparable in this respect.

### HOW A DANGER METER WORKS

SUPPOSE IT IS APRIL 20, 6 DAYS SINCE IT RAINED 0.65 INCHES, WIND IS BLOWING 6 MILES PER HOUR, FUEL MOISTURE IS 5 % AND GRASSES, WEEDS AND SHRUBS HAVE NOT YET BECOME GREEN.

### FOREST FIRE DANGER METER

FOR USE IN THE MOUNTAINOUS REGIONS OF THE EASTERN UNITED STATES

| SEASON OF YEAR          |                       |              |                    |                    |   |
|-------------------------|-----------------------|--------------|--------------------|--------------------|---|
|                         | MARCH 1               | TO APRIL 15  | SEPT. 1 TO OCT. 15 | OCT. 16 TO FEB. 28 |   |
| AMOUNT OF LAST RAIN     | APRIL 16 TO AUGUST 31 | —            | —                  | —                  | — |
| 0.25" TO 0.50"          | 12+ 6-9 2-4           | 14+ 7-11 3-5 | 16+ 9-13 4-6       |                    |   |
| 0.51" OR MORE           | 10+ 5-7               | 12+ 6-9      | 14+ 7-11           |                    |   |
|                         | G T C                 | G T C        | G T C              |                    |   |
| CONDITION OF VEGETATION |                       |              |                    |                    |   |
|                         |                       |              |                    |                    |   |

| FUEL MOISTURE CONTENT IN PERCENT |              |              |              |             |                    |
|----------------------------------|--------------|--------------|--------------|-------------|--------------------|
| WIND VELOCITY IN MILES PER HOUR  | 25.1 OR MORE | 18.6 TO 25.0 | 12.6 TO 18.5 | 7.6 TO 12.5 | 4.0 TO 7.5 OR LESS |
| 0 TO 1.4                         | 1            | 1            | 2            | 3           | 3 4                |
| 1.5 TO 3.4                       | 1            | 1            | 2            | 3           | 3 4                |
| (3.5 TO 7.4)                     | 1            | 2            | 2            | 3           | 4 4                |
| 7.5 TO 12.5                      | 1            | 2            | 3            | 4           | 4 4                |
| 12.6 TO 18.5                     | 1            | 2            | 3            | 4           | 4 5                |
| 18.6 OR MORE                     | 1            | 2            | 3            | 4           | 5 5                |
| CLASS OF FIRE DANGER             |              |              |              |             |                    |
|                                  |              |              |              |             |                    |

(SEE INSTRUCTIONS ON REVERSE SIDE.)

ANSWER  
CLASS 4 DANGER

Both meters express relative degree of danger only. Actual rate of spread of fire is another matter and depends partially on factors not considered in the danger rating system, particularly kind of fuel, its volume and arrangement, and the topography of the region.

## Relation Between Danger Measurement and Organization

Integration of fuel and weather measurements into danger classes is not an end in itself. The fire control organization necessary to insure adequate detection at all times and proper speeds and strengths of attack in all fuel types should be set up for each danger class.

The determination of the proper organization that should accompany each danger class has to be based on study of normal fire occurrence, fuel types, and values at stake, and must be modified when necessary on the basis of current visibility and abnormal fire occurrence. Such considerations tell where and how many facilities should be employed. Danger ratings tell when these facilities must be made available.

A brief description of the way each major consideration fits into the philosophy of fire control planning is needed to illustrate the function of fire danger measurement.

### Objectives

It is not the purpose of this technical note to discuss at length the various fire control objectives. However, objectives must be decided upon before planning can be undertaken, since they govern the choice of detection, travel time, and suppression standards--the primary controls of the type and strength of organization adopted.

### Occurrence

The normal frequency of fires is a basic consideration in location of lookout towers, patrol routes and suppression crew stations. Areas where fires are concentrated should have the best coverage and fastest attack, other things being equal. The analysis of fire occurrence by causes also indicates where and what type of prevention work is necessary.

In the East where 98 percent of fires are man-caused, abnormalities and sudden shifts in the activity of fire starting agencies can not be anticipated or measured until after fires occur. Therefore, there is little possibility of bringing this temporary or changing aspect of risk into a danger rating system. About all that can be done is to vary scheduled organization when there is some local evidence, such as seasonal tobacco-bed burning, to indicate greater chance of fires starting. The following figures (obtained from analysis of 467 fires occurring in the southern Appalachians, 3,247 fires in New England, about 780 in New Jersey, and 150 in

South Carolina) indicate the probability of occurrence on days of different danger classes. Such data can be used to guide organization planning on the basis of occurrence although these figures are preliminary and may depart somewhat from long-time averages.

#### Probability of Occurrence

| Fire danger class | Southern Appalachians | New England | New Jersey | South Carolina coastal plain |
|-------------------|-----------------------|-------------|------------|------------------------------|
| 1                 | 1                     | 1           | 1          | 1                            |
| 2                 | 2                     | 7           | 6          | 4                            |
| 3                 | 8                     | 20          | 15         | 13                           |
| 4                 | 23                    | 67          | 47         | 24                           |
| 5                 | 56                    | (No data)   | 150        | 137                          |

Thus, the probability of a fire occurring is 56 times as great on a class 5 day as on a class 1 day in the southern Appalachians.

#### Fuel Types

A classification of fuel types from the standpoint of rate of spread and resistance to control completes the picture of the fire control job to be handled by a given organization. Expected rate of spread indicates the length of fire line to be built, resistance to control indicates the difficulty of constructing the line for a given fuel type. Together, rate of spread and resistance to control measure required man-power, which, multiplied by normal occurrence, gives the total fire job. Such information is essential in the determination of every phase of man-power placement, location of communication and transportation facilities, and strength of attack.

Rate of spread and resistance to control data for each fuel type by danger classes would be very valuable but such information is not yet available. Instead, average rates of spread for several hardwood types (Appalachian Mountain) and several pine types (Coastal Plain) constitute the data available at this time for the East. Some of these figures are given on the following page but it is emphasized that danger class provides at best a rough index of rate of spread. Fuel type and topography have an extremely important influence on fire behavior.

| <u>Fire Danger Class</u> | <u>Rate of Spread in Chains Perimeter Per Hour</u> |   |
|--------------------------|--|---|
|                          | <u>Hardwood fuel types</u><br>(basis 524 fires)    | <u>Pine fuel types</u><br>(basis 234 fires) |
| 1                        | 2  | 9   |
| 2                        | 6  | 27  |
| 3                        | 10   | 46  |
| 4                        | 15   | 72  |
| 5                        | 18   | 120   |

### Values

Values at stake are a requisite of organization planning although some agencies do not consider them. Theoretically, at least, the fastest action and the strongest attack should be provided on areas where the greatest loss from fire will occur if all other things are the same. For example, on a class 3 day, a stronger force should be available on a watershed producing a city's water supply than on another area with similar timber values but not a part of the watershed.

### Visibility

In eastern fire danger rating schemes visibility distance, although a factor that changes from day to day, is not included as a variable on the danger meter but rather is considered in organization plans. A smoky atmosphere does not directly affect fire behavior. Therefore, it seems more reasonable to vary the detection organization as visibility changes because if a certain detection time standard is maintained, strength of attack does not need to change with visibility distance.

To sum up, sound fire control planning, basic to every phase of fire control, first requires an inventory of occurrence, fuels and values. To the relative classes into which the total range of danger is divided, required organization procedures, determined from this inventory, are assigned. The danger meter indicates the relative severity of burning conditions, but "what to do about it" is a function of the organization plan. Organization plans for a typical national forest in the southern Appalachians are presented in graphic form on accompanying pages.

### Specific Uses

Those who have used fire danger ratings have found that numerical classes, determined from measurements instead of guesses, have helped them handle their fire control jobs more effectively.

The originators of the fire danger measuring system in the West probably had no idea at first of the extent to which danger ratings might be used. Even yet there is not complete understanding of how ratings may help in all phases of fire protection and even more important, of what are the limitations to their application. A list of some of the uses of these ratings has been prepared and is discussed below.

#### Application in Fire Prevention

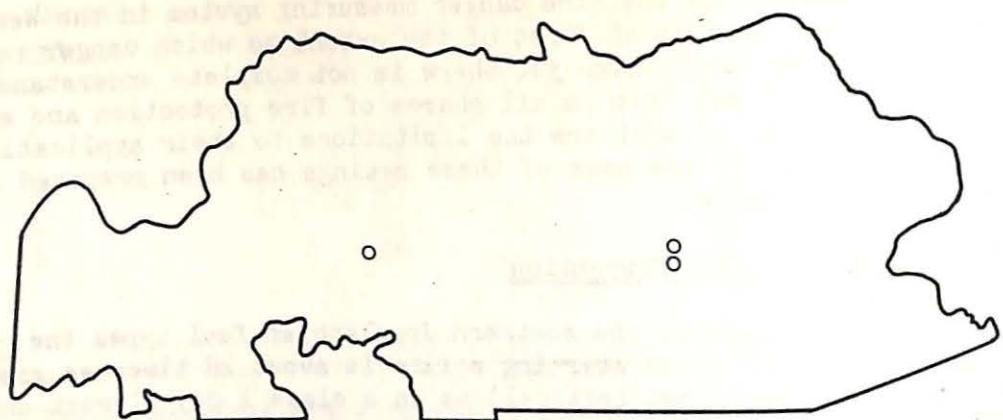
1. In some of the southern Appalachian fuel types the chance of a fire brand starting a fire is about 28 times as great on a class 5 day (most critical) as on a class 1 day (lowest danger). Thus, fire danger ratings can be used to indicate relative "ignitability" of similar fuels. Presumably, there are just as many cigarettes and matches discarded, as many locomotive sparks scattered, and as many other fire-starting agencies active (except debris burners and incendiaries) on days of high danger as on days of lesser danger.

In any test of the effectiveness of a fire prevention campaign the danger existing during the period must be considered, otherwise a reduction in the number of man-caused fires due to favorable weather conditions might be mistaken for good prevention technique. Conditions that influence the ease of ignition can be considered in studies of the efficiency of prevention work if fire danger ratings are available.

2. Danger ratings can be used to show the need for better legislation to control the use of fire. If the majority of forest fires caused by debris-burning operations originate on days of high danger, it is very evident that restrictions (other than calendar date, which is almost meaningless) should be placed on such activities. For example, in a portion of one state in the southern Appalachians, 76 percent of fires that escaped from debris burners over a 6-year period did so on class 4 and 5 days, the 2 highest danger classes.

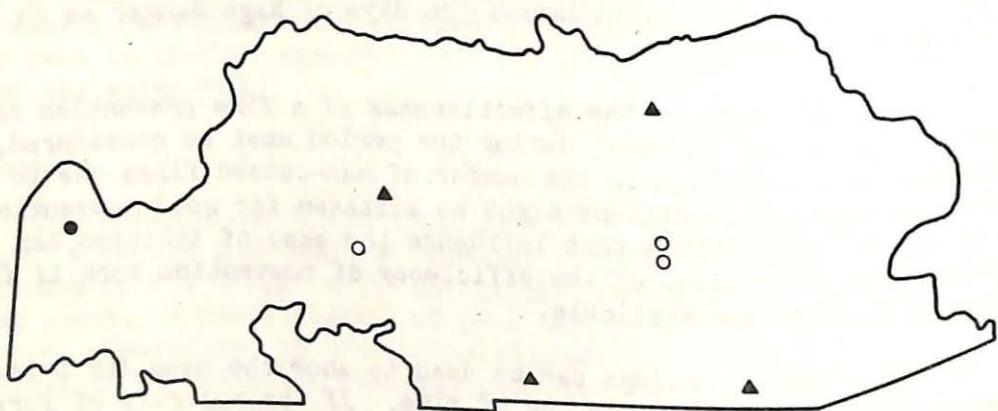
3. Danger ratings serve as useful guides in the current regulation of prevention measures such as closure or reopening of woods to entry, restrictions on smoking, on debris burning, and on campfires. The use of comparable danger rating schemes can eliminate annoying variations in regulation by adjacent states or different agencies within a state. Lack of uniformity resulting from variations in judgment confuses the public and destroys its confidence in forest fire prevention agencies. In the far East and South, where recreation and other forms of public use are especially important, national forests, national parks, Indian reservations,

# FIRE ORGANIZATION PLAN FOR



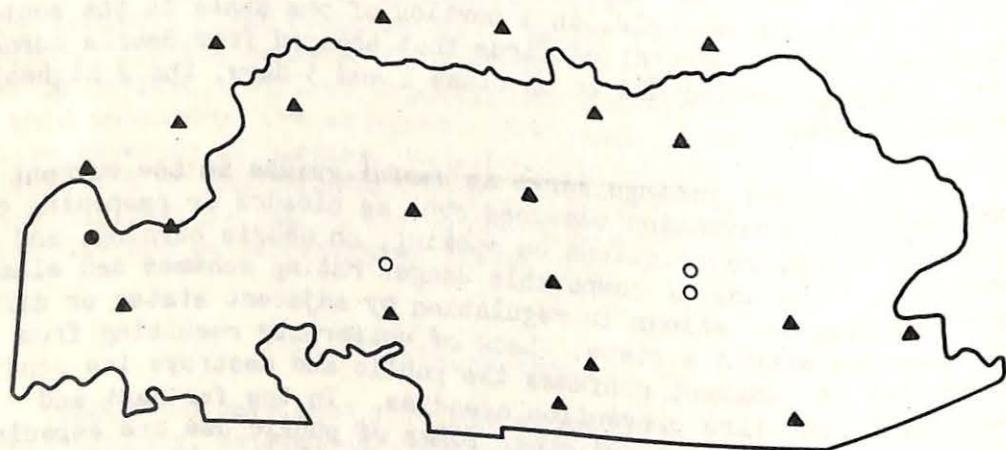
CLASS 1

NO MEN ESPECIALLY DETAILED TO FIRE CONTROL.  
REGULAR FOREST ORGANIZATION ON NON-FIRE PROJECTS



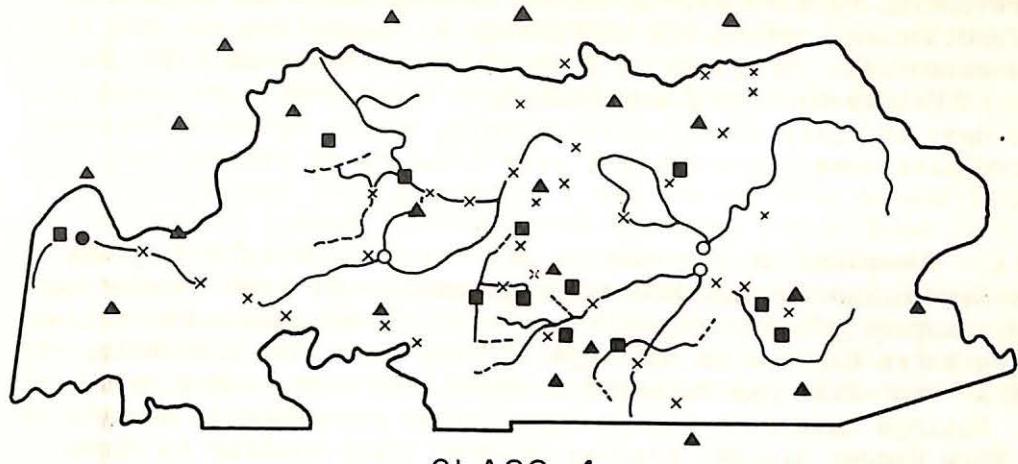
CLASS 2

KEY LOOKOUT STATIONS MANNED



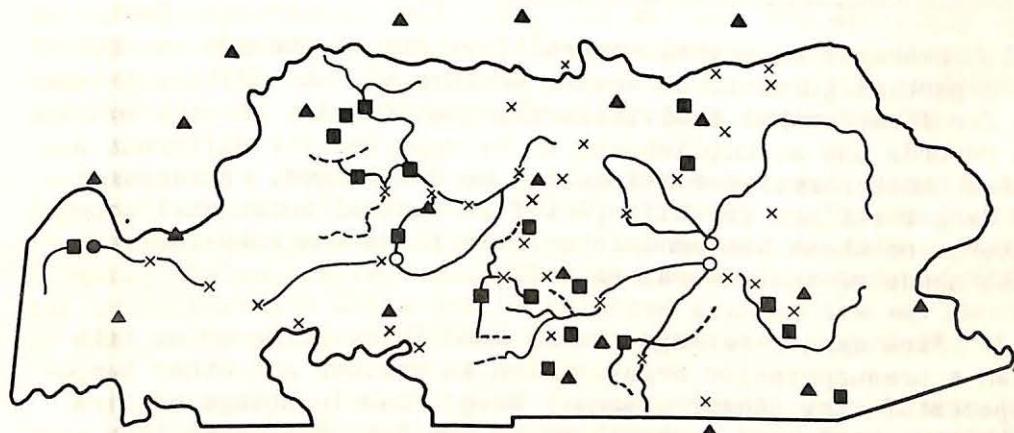
CLASS 3  
ALL DETECTION STATIONS MANNED

# THE NANTAHALA NATIONAL FOREST



CLASS 4

ONE OR MORE SUPPRESSION CREWS IN OR NEAR CAMP, OTHERS PROVIDED WITH TELEPHONE COMMUNICATION. WARDENS NOTIFIED OF DANGER PATROLS USED ONLY WHEN VISIBILITY IS LESS THAN 5 MILES.



CLASS 5

CREWS SPOTTED AT ESPECIALLY HAZARDOUS LOCATIONS. PLANS FOR FOLLOW-UP REPLACEMENT PUT INTO EFFECT. PATROLS USED ONLY WHEN VISIBILITY IS LESS THAN 5 MILES.

## LEGEND

|                        |                   |
|------------------------|-------------------|
| ○ RANGER OR SUPERVISOR | ■ CREW            |
| ▲ LOOKOUT STATION      | ~ MOTOR PATROL    |
| ● GUARD                | - - - FOOT PATROL |
| × WARDEN               |                   |

state departments and many private agencies individually practice fire prevention to some extent. With so many different organizations functioning, reasonable uniformity in regulating the use of fire is essential. In parts of 7 New England states in 1939, 72 percent of debris-burning fires that "got away" did so on class 3, 4, or 5 days in spite of an active burning permit system. This would indicate more rigid control over issuance of permits is needed.

4. Numerical danger ratings are readily understood by the average layman and can therefore be advantageously used to educate hunters, campers, fishermen, and tourists. These people are willing to be extra careful on bad days if they know that the definition of a "bad" fire day is based on something more than a mere guess. Ratings have much public appeal when presented in showy form. Fire danger display boards, colored flags similar to storm warnings, and a large variety of showy displays have been worked out on the basis of measured fire danger classes to educate and interest the general public and users of the forests.

#### Use of Fire Danger Ratings in Presuppression

1. Averages of several years' fire danger records can be used as a partial guide to determine whether or not additional expenditures for fire control activities are justifiable. On the basis of such records the accomplishment to be expected for different expenditures under normal conditions can be determined. An accumulation of danger ratings for different fire control units will show legislators and those who administer fire funds the comparative financial needs of the several units.

2. Fire danger ratings can be used in building up or cutting down a presuppression organization as weather and other temporary aspects of fire danger change. When a man in charge of fire control hires guards and lookout men by the day, employing them only when it is "dry", and depending on his own or someone else's judgment, sometimes men are on the job when they are not needed, and at other times they are not available when they should be. With an organization planned to function on the basis of fire danger ratings, however, lookout men, patrolmen, guards, and crews go on fire duty when they are needed. Likewise during periods of low danger these men can be safely used on nonfire projects. If fire danger actually differs between ranger or warden districts, then the operation of lookout towers varies correspondingly and the district dry enough to have fires has its lookout points manned.

3. A danger rating scheme indicates unseasonable periods of fire weather and prevents fire control organizations from getting

caught unprepared in off-season letdowns. In some sections of the country long fire seasons are not as common as short periods of high fire danger occurring throughout the year. Some of the most disastrous fires have resulted from the inability of fire men to recognize the development of a dangerous period in time to be prepared for it.

4. Danger ratings assist a new man or even an old-timer in new country to become familiar with his fire job without having to learn by costly experience. He may analyze past records and see what actual fires have done under specific measured conditions. He can understand and interpret such records, being sure that they are not influenced by someone's personal opinions, for danger ratings are just as specific as the measurement of distance in feet or time in minutes.

5. Comparability of man-power needs between 2 or more fire control units can be determined most logically only if ratings of normal danger are available. Fire danger measurement provides part of the information essential in judging whether districts or forests are comparably manned. Although other considerations, such as normal occurrence, fuel type, and values, are extremely important in such a determination, they are not complete without the knowledge of normal fire danger compiled to show the seriousness and duration of conditions confronting each organization.

6. Fire danger ratings, which are numerical classes and not indefinite terms like "good", "bad", or "very bad", permit exact comparisons of the severity of conditions in 2 or more districts, forests, states, or regions. Thus the accomplishments of different administrative units can be balanced against the seriousness of fuel and weather conditions under which each organization worked.

For example, scarcity of fires and smallness of area burned have often been misconstrued as evidence of good fire prevention and suppression, whereas the real reason was a very easy fire season. Conversely, a good fire record might be taken to indicate an easy fire problem, whereas the accomplishment was really the result of exceptionally fine work by the fire control organization in spite of critical weather. Obviously the efficiency of a fire control organization should not be judged only on the basis of fires and acres burned.

7. Fire danger ratings make possible exact comparisons of seriousness of fire seasons by years for any unit. It is quite useful to be able to compare a current year's accomplishments in fire control with those of past years. Also, in planning the financial aspects of fire control it is desirable to know the

frequency of critical and easy years. Danger ratings form a valid base for such a classification.

8. Standardization of fire danger terminology through use of numerical danger classes is especially valuable in showing the need for cooperative fire funds and in justifying their use. Where mutual interest in a fire control job makes it desirable for 2 organizations to join their efforts or pool their facilities it is just good business to be able to determine what the money of each division is "buying." Danger measurement helps in doing this.

#### Fire Danger Ratings Assist Suppression

Not only does the pre-fire distribution of man-power on the basis of measured fire danger insure faster action when a fire does start, but the fire danger ratings can also be used as an aid in the actual suppression of fires by dispatchers and fire bosses who have a knowledge of fire behavior by danger classes in different fuel types. Measurements of existing danger serve as guides for dispatchers in sending men to fires in numbers commensurate with the classes of danger prevailing. Fire bosses are likewise guided in reducing the man-power on a fire as danger decreases. It is re-emphasized here that other factors affecting rate of spread and resistance to control must be carefully considered in dispatching. Fire danger rating is only one of several important factors.

#### Danger Ratings Applied to Damage Appraisal

Ratings of fire danger can be used to indicate the intensity of a fire in a given fuel type. This information, in turn, is essential to the proper rating of fire damage, especially in hardwood and some southern pine types. Most fire control organizations do not now have the personnel available to make a detailed survey of each burned area and must rely on generalized tables to ascertain damage after a fire. The most practical way to approximate damage in a known stand of timber is to correlate it with fire intensity as indicated by danger measurements. In some types mortality may cumulate for 5 or more years after a fire, the damage varying, of course, with fire intensity. In some instances it is desirable to initiate legal proceedings to collect fire damages. These can not wait for a 5th-year examination to be made to determine total mortality. A danger rating, obtained during the fire, often serves as an index of expected losses that hinge on fire intensity.

#### Danger Rating as Guides in the Silvicultural Use of Fire and in Hazard Reduction

If the use of fire should be found advisable in silvicultural practice and in hazard reduction, fire danger ratings are

helpful as indicators of times when such use is safe. A good understanding of the severity of fire expected for different classes of danger takes much of the guess-work out of burning planned to improve game food supplies, stand composition, seedbeds, and certain other conditions involved in the management of forest resources. Danger ratings have a place, too, in controlled burning for protection in that they help determine when maximum fuel reduction with minimum damage or risk can be obtained. Hundreds of miles of strip between parallel plowed fire lines is burned every year in the South where firebreaks are maintained. More efficiency is obtained from the burning crews if their activities can be guided by measured danger. The best job is obtained with the least undue risk.

### Conclusion

Because of its simplicity and utility fire danger measurement should play an important part in the successful operation of any fire control organization. Danger rating systems suitable for use in hardwood types and pine forests of eastern United States have been developed. While there is no precise way to evaluate the dollars and cents return from the use of danger measurements, it is significant that not a single fire control organization that has given the method a thorough test has ever concluded that it has not paid its way. A statement by one South Carolina ranger after his first season using a danger rating system is illustrative; "Last spring I had 62 fires against 63 for the same period this year. My burned acreage this year was but 19 percent of that burned the year before. I attribute this improvement primarily to the danger rating system which helped us plan this year to have the fire organization in the right places at the right times."

### INSTRUMENTS AND WEIGHING SHELTER WITH PLANS FOR MOUNTING AND ERECTING

A fuel moisture scale and set of fuel moisture indicator sticks, rain gauge, anemometer, and weighing shelter comprise the entire list of equipment needed at a fire danger station. The following information will be helpful in planning for such a station.

#### Essential Instruments

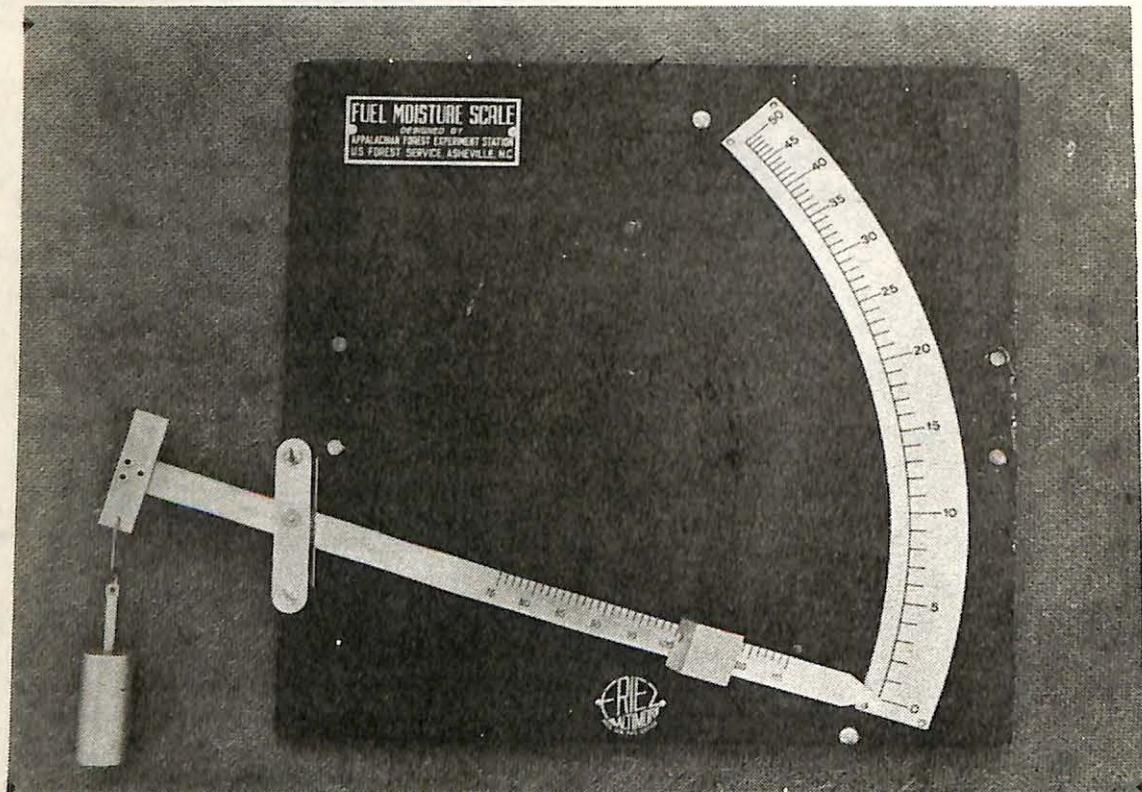
##### Fuel Moisture Scale

The fuel moisture scale, developed by Byram of the Appalachian Forest Experiment Station, is used to determine the moisture

content of fuel moisture indicator sticks. The instrument consists of a pivoted balance arm or beam mounted on a lacquered 10 by 10 inch metal back. A sliding weight or counterbalance on the beam is used to adjust the scale for sets of sticks of different oven-dry weights from 75 to 115 grams.

The balance arm of the instrument has a small hook on the left end to which a set of wood sticks is attached when a reading is to be obtained. The other end points to the average moisture content of the sticks, shown on a curved scale graduated from zero to 50 percent.

The balance arm pivots on a nickel-silver pin. All other parts except the back are of solid brass, nickel plated. A standard 100-gram test weight accompanies each instrument and is used as a ready method of leveling the device to obtain the zero setting as shown in the accompanying illustration. Each scale is packed in a wooden box suitable for shipping. Detailed specifications may be obtained from the Appalachian Forest Experiment Station, Asheville, North Carolina.



Tests show that in low ranges the instrument will indicate true moistures within  $\pm 0.1$  percent, while at 50 percent the error that may be expected is  $\pm 0.5$  percent.

Instruments may be obtained from the following manufacturers. The costs shown are approximate and may change currently.

Julien P. Friez and Sons  
Division of Bendix Aviation Corporation  
Baltimore, Maryland..... \$13.50 each

Walter F. Backus  
3713 S. E. Division Street  
Portland, Oregon..... \$17.50 each

A satisfactory mounting for the scale in a weighing shelter is described on page 28 and is illustrated on page 29.

#### Fuel Moisture Indicator Sticks

The Appalachian type of fuel moisture indicator sticks, made from basswood Venetian blind stock, can be obtained free of charge from the Appalachian Forest Experiment Station, Asheville, North Carolina. A calibration card, enclosed with each set of sticks, shows the proper settings of the sliding adjustment on the balance arm of the scale.

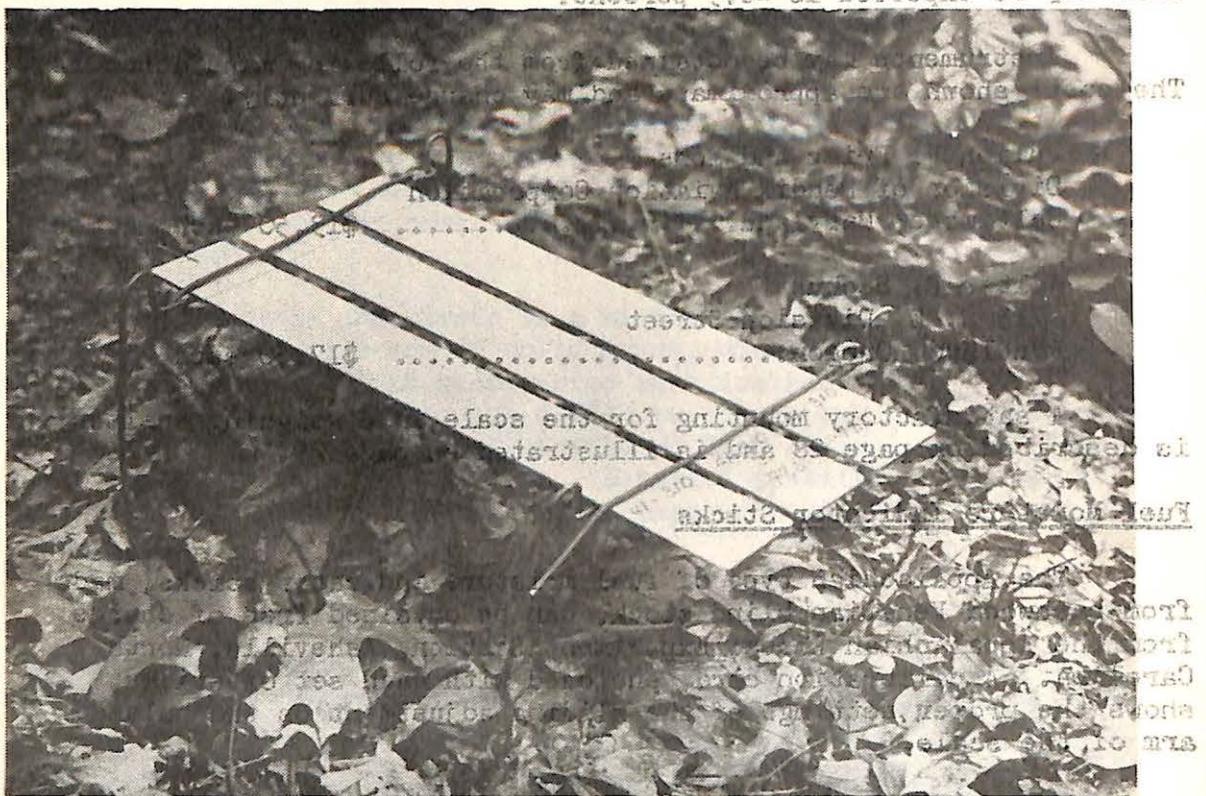
When sticks are lost, broken, or chipped, a new set should be requested at once. Sets in use more than 6 months should be replaced. A set of sticks in typical exposure is shown on page 22.

#### Rain Gauges

A rain gauge consists of a sharp-edged, funnel-shaped, receiver that concentrates precipitation into a small metal measuring tube housed in a larger metal container. The "catch" of rain is measured with a small graduated ruler or measuring stick. The ratio of receiver area to that of the tube is 10 to 1. Therefore, an inch of water in the tube indicates but 1/10 inch of rain.

The standard rain and snow gauge, Weather Bureau pattern, may be obtained from Julien P. Friez and Sons, Division of Bendix Aviation Corporation, Baltimore, Maryland, at a unit cost of about \$14.00. The Taylor Instrument Companies, Rochester, New York, sell the same type of gauge for \$17.00. United States Government agencies may obtain this pattern of gauge at a contract price of \$7.90 from W. S. Jenks and Son, 723 Seventh Street, N. W., Washington, D. C. The gauge retails at a starting price of \$8.50,

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complete. This is not a complete list of manufacturers and the  
prices quoted are for instruments that differ somewhat in construction  
although they are all standard Weather Bureau pattern. In  
general, the Weather Bureau pattern is the best gauge available and  
is about 30 inches high and 8 inches in diameter. It is  
similar to "No. 10"雨量計. 延長度数 10cm は 10cm が  
ed Most dangerous stations use the Forest Service rain gauge.

This is a much cheaper instrument than the standard type but just as  
satisfactory. It is made of galvanized iron and is about 12 inches  
inches high and slightly less than 8 inches in diameter. In other  
respects it resembles the larger gauge. Comparative tests con-  
ducted by Gisborne in northern Idaho and by the Appalachian Station  
indicate that the Forest Service pattern is satisfactory.

Forest Service rain gauges can be obtained at a cost of  
\$2.25 each from F. A. Anderson Manufacturing Company, 214 N. W. 20th  
Flanders Street, Portland, Oregon, or for \$4.95 each from Dozier  
Manufacturing Company, 4223 Grove Street, Oakland, California.

When measuring sticks are broken, replacements may be obtained from the Davis White Company, 315 W. Court Street, Milwaukee, Wisconsin, or William C. Ballantyne, 1421 F Street, N. W., Washington, D. C., at a cost of about 20 cents each.

Rain Gauge Support. Rain gauges should be securely supported so that the funnel top is level and about waist high. A Forest Service gauge will fit inside a square box formed by nailing together four 1 by 10 inch pine boards. This box, when fastened to the top of a post, makes a convenient and substantial support for the gauge. A neater appearing support, suggested for permanent stations, is diagrammed on page 24. This has been adapted from the U. S. Weather Bureau type and may be used for either the Forest Service or Standard rain gauge by adjusting the bottom so that the rim of the receiver is 2 inches above the box.

#### Anemometers

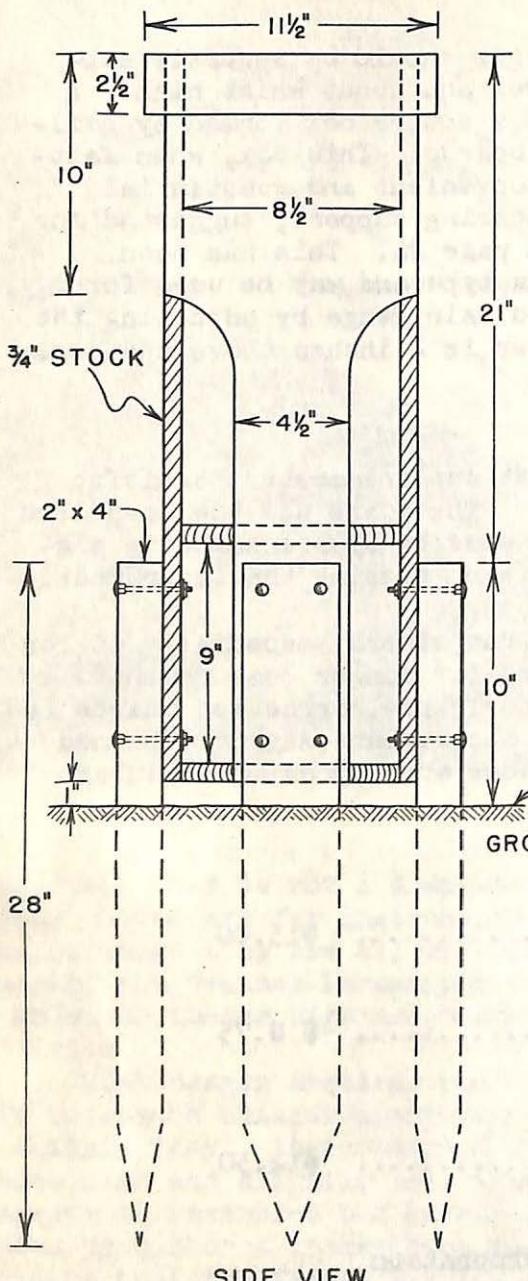
There are a variety of low-cost cup anemometers satisfactory for use at fire danger stations. These are all the so-called "buzzer" type that indicate current velocity by transmitting signals or buzzes for each 1/60 mile of wind passing the instrument.

Some types are more accurate than others, especially at low velocities, but all can be recommended for danger measurement. All anemometers, except the Dozier model, use correction charts to convert indicated to true velocity. Instruments may be obtained from the following manufacturers; prices are approximate and are for single instruments:

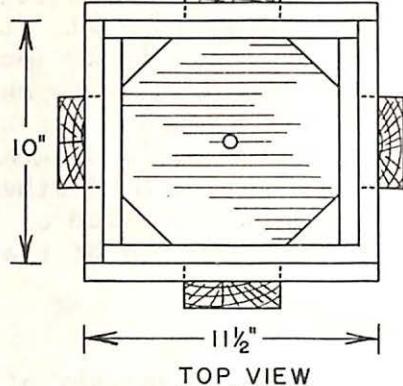
|   |         |
|---|---------|
| Dozier Manufacturing Company<br>4223 Grove Street<br>Oakland, California.....                   | \$15.00 |
| M. C. Stewart Company<br>Ashburnham, Massachusetts.....   | \$ 8.75 |
| A. E. Chisholm<br>2640 E. Burnside Street<br>Portland, Oregon.....                              | \$12.50 |
| Julien P. Friez and Sons<br>Division of Bendix Aviation Corporation<br>Baltimore, Maryland..... | \$18.00 |

None of the above instruments comes equipped with a mounting device but all have bases threaded to fit a standard 1/2 inch pipe thread, except the Friez instrument which fits a 3/8 inch threaded

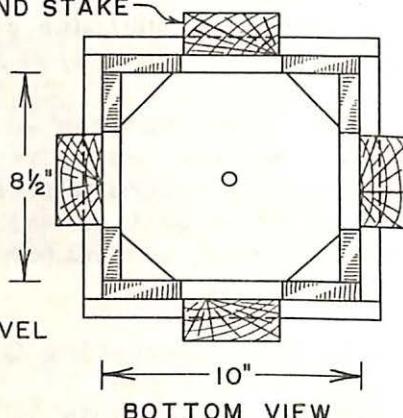
# DIMENSIONS OF RAIN GAUGE SUPPORT



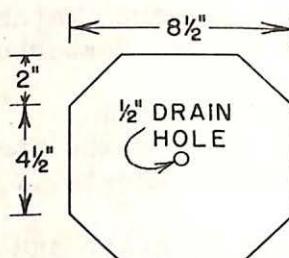
GROUND STAKE



GROUND STAKE



PARTITION



| BILL OF MATERIALS |   |
|-------------------|---|
| No. Pieces        | Size and Description                      |
| 2                 | 3/4" x 10" x 30" - Sides of support       |
| 2                 | 3/4" x 8 1/2" x 30" - Sides of support    |
| 2                 | 3/4" x 8 1/2" x 8 1/2" - Partitions       |
| 2                 | 3/4" x 2 1/2" x 11 1/2" - Molding for top |
| 2                 | 3/4" x 2 1/2" x 10" - Molding for top     |
| 4                 | 2" x 4" x 28" - Ground Stakes             |
| 16                | Corriage bolts - Length 3" - Diam. 1/4"   |
| 16                | Wrought iron washers - Inside diam. 3/8"  |
| 1/2 lb.           | Six penny box nails                       |

(Design adapted from support used by U. S. Weather Bureau)

pipe. Suitable iron pipe mountings are diagrammed on the next page, either one being satisfactory. All wire, batteries, buzzers, and switches necessary to complete the signal circuit can be purchased at any hardware store. Two  $1\frac{1}{2}$ -volt dry cell batteries will supply the necessary current unless the circuit is long. A small electric buzzer or flasher bulb provides the best signal and a single-bladed knife switch is recommended.

Although the 1/60-mile transmitters are satisfactory for fire danger measurement, there is some advantage in having cumulated wind movement, for a more reliable average can then be obtained. The Dozier Manufacturing Company makes a watch-like wind mileage recorder and velocity meter which shows total wind movement when attached to any buzzer type anemometer. These attachments sell for \$19.00 each. The M. C. Stewart Company manufactures an electric counter which attaches to any 1/60-mile transmitter. It retails for \$10.00.

Standard anemometers of high quality, with dials from which total wind movement to the nearest 1/10 mile can be read, may be purchased from the Julien P. Friez Company for prices starting at \$80.00. Instruments can also be obtained with the additional 1/60-mile transmitting feature.

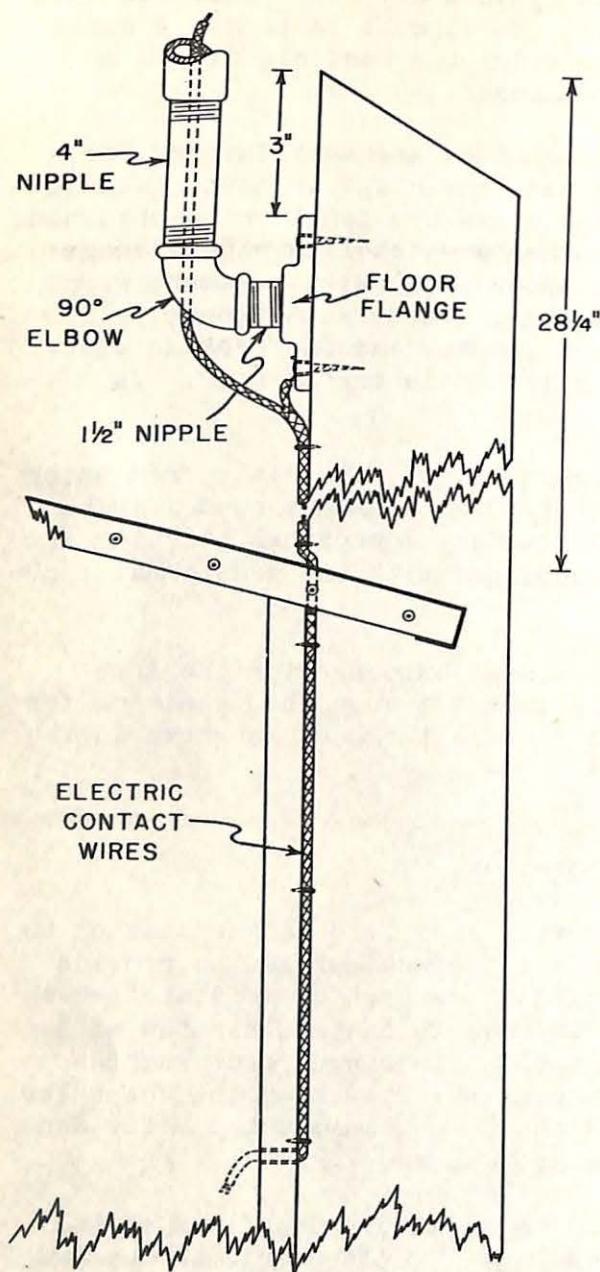
The standard height of anemometer exposure for the Appalachian danger rating systems is 8 feet. A suggested position for mounting the instrument on top of the shelter post is shown in the illustration on page 6.

#### Weighing Shelter

A weighing shelter is necessary at a fire danger station to protect the fuel moisture scales from the weather and to provide shelter from the wind during the actual process of moisture determination. It is also convenient to have in one shelter the wind circuit batteries, switch, and buzzer. Other equipment such as test weight for scales, rain measuring stick, weathering chart for indicator sticks, wind correction chart, and instructions for danger station operation may also be kept there.

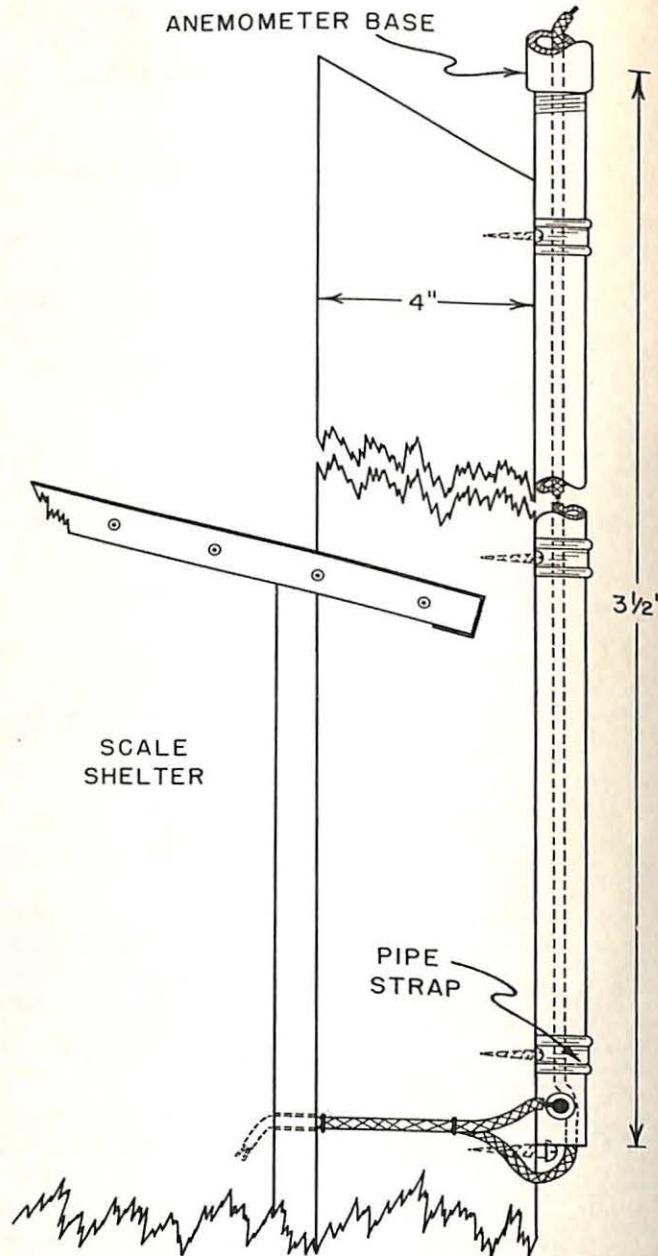
The weighing shelter should be a weather-proof box of the dimensions shown in the drawing on page 27. It should be mounted substantially on a post that is set in a concrete base to eliminate vibration and shifting of the shelter due to wind and settling of the ground. A full-sized hinged door on the front of the shelter is most convenient and gives the observer plenty of room in which to work. Materials for one shelter can be purchased for \$6.00 or

# ANEMOMETER MOUNTING



## MATERIALS

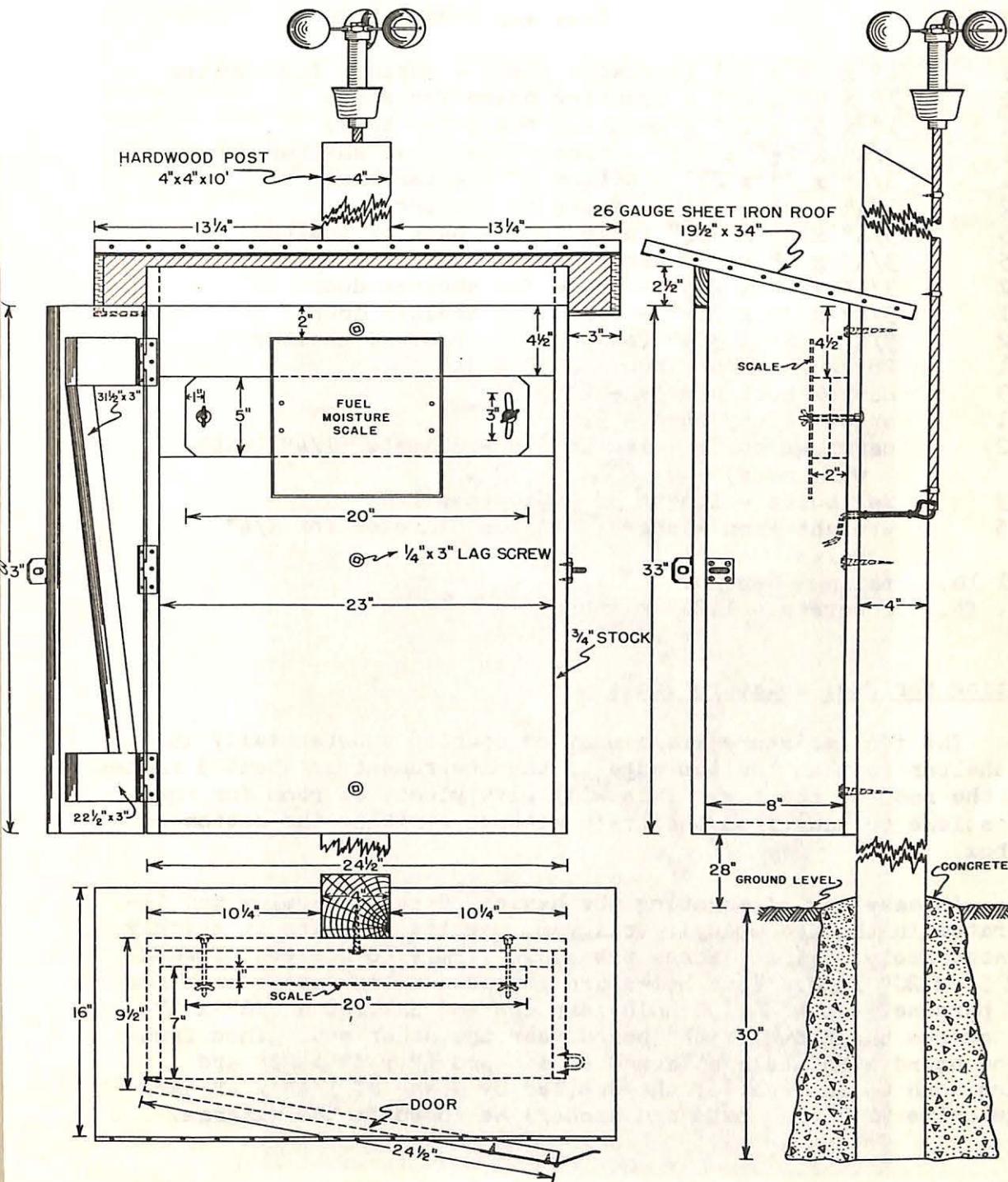
- 1 FLOOR FLANGE TO FIT  $\frac{1}{2}$ " PIPE
- 1 NIPPLE FOR  $\frac{1}{2}$ " PIPE - 1 $\frac{1}{2}$ " LONG
- 1 ELBOW 90° FOR  $\frac{1}{2}$ " PIPE
- 1 NIPPLE FOR  $\frac{1}{2}$ " PIPE - 4" LONG



## MATERIALS

- 1 LENGTH  $\frac{1}{2}$ " PIPE - 3 $\frac{1}{2}$ ' LONG
- 5 PIPE STRAPS FOR  $\frac{1}{2}$ " PIPE

## DIMENSIONS OF WEIGHING SHELTER



\$7.00. These materials are listed below.

BILL OF MATERIALS FOR WEIGHING SHELTER

| No. Pieces | Size and Description  |
|------------|---|
| 1          | 4" x 4" x 10' (hardwood post) - support for shelter                           |
| 1          | 1" x 5" x 20" - mounting board for scale                                      |
| 1          | 1" x 5" x 23" - mounting board for scale                                      |
| 1          | 3/4" x 2 $\frac{1}{2}$ " x 24 $\frac{1}{2}$ " - crosspiece above shelter door |
| 1          | 3/4" x 8" x 23" - bottom of shelter box                                       |
| 2          | 3/4" x 8" x 35 $\frac{1}{2}$ " - sides of shelter box                         |
| 5          | 3/4" x 6" x 33 $\frac{1}{4}$ " (ship lap) - back of shelter                   |
| 5          | 3/4" x 6" x 33" (ship lap) - door of shelter                                  |
| 2          | 3/4" x 3" x 22 $\frac{1}{2}$ " - brace for shelter door                       |
| 1          | 3/4" x 3" x 31 $\frac{1}{2}$ " - brace for shelter door                       |
| 2          | 3/4" x 8" x 30 $\frac{1}{2}$ " (ship lap) - roof of shelter                   |
| 1          | 26 gauge sheet iron - 19 $\frac{1}{2}$ " x 34"                                |
| 3          | narrow butt hinges - 2" x 3"  |
| 1          | steel safety hasp - 3 $\frac{1}{2}$ "   |
| 2          | carriage bolts - length 3 $\frac{1}{2}$ " - diameter 1/4" (with wing nuts)    |
| 3          | lag bolts - length 3" - diameter 1/4"   |
| 5          | wrought iron washers - inside diameter for 1/4" bolts                         |
| 1 lb.      | nails - 6-penny   |
| 2 cu. ft.  | concrete - 1:2:3 mixture  |

Mounting for Fuel Moisture Scale

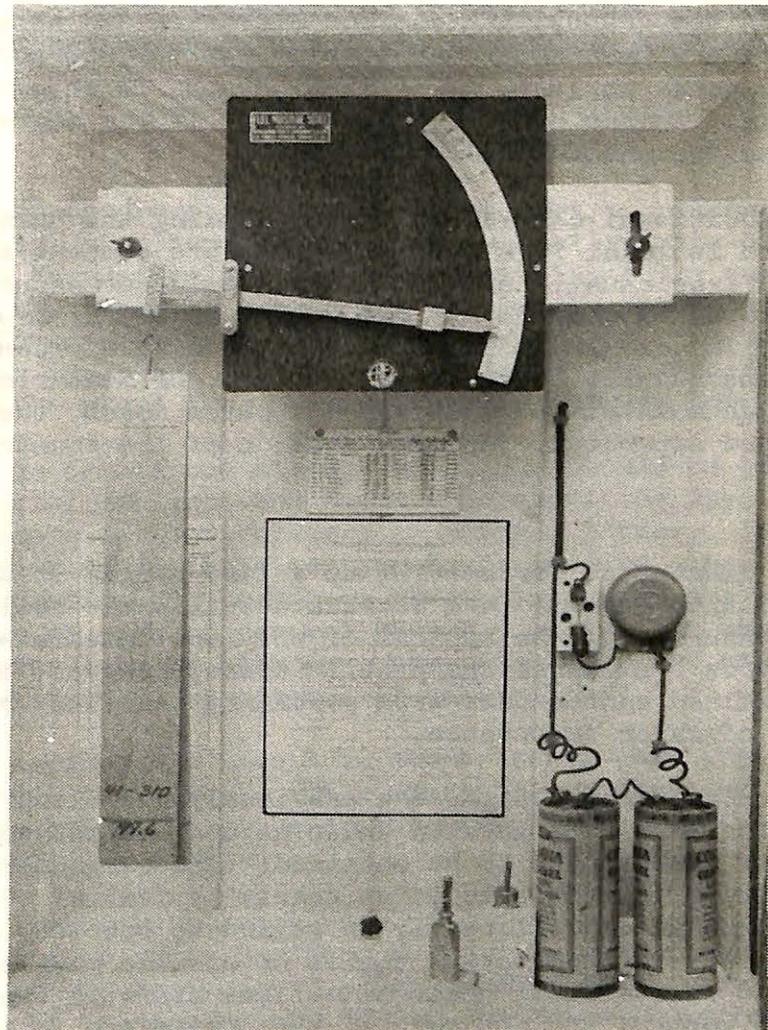
The fuel moisture scale must be mounted substantially in the shelter so that the top edge of the instrument is about 3 inches from the roof of the box. This will give plenty of room for the wood sticks to hang from the scale without striking the bottom of the box.

An easy way of mounting the device, described below and illustrated in the accompanying diagram, permits leveling it quickly and accurately. First, screw the scale firmly to a piece of wood 1" x 5" x 20" long. Four holes are provided in the scale back for this purpose. Bore a 1/4" hole near one end and cut a 3/8" x 3" slot across the width of the board near the other end. Then fasten the board with scale attached to a board 1" x 5" x 23" and secure both to the rear of the shelter by means of 1/4" x 4" carriage bolts with wing nuts and washers as shown in the diagram.

The crosspiece holding the scale should be approximately level. The slot will permit precise leveling of the scale before the wing nuts are tightened. It may be leveled again if the ground settles and tips the shelter slightly from the vertical.

#### Arrangement Inside Shelter

The accompanying picture illustrates a neat and convenient arrangement for each item housed within the weighing shelter. Beneath the scales (at top center) is fastened the weathering correction card for wood sticks. At the left, behind the wood sticks is a card showing corrections for wind readings. The large sheet in the center of the shelter gives instructions and points (reproduced in the appendix) which the observer must continually watch



in operating a station. Buzzer, switch, batteries, test weight, and can of anemometer oil are to the right and the rain measuring stick hangs at the side of the shelter.

## OPERATION OF THE FIRE DANGER MEASURING SYSTEM

### Selection of Fire Danger Stations

#### Number

The number of stations required to sample adequately the major differences in fuel moisture and weather conditions depends primarily on topography; that is, on elevation and aspect. In the mountains of the East about one station per 150,000 acres or one per 300,000 acres in level or rolling country is enough to begin with. "Holes" in the network will show up if the degree of sampling is insufficient.

An additional consideration in deciding the number of stations needed is local fire occurrence. Where concentrations of man-caused fires usually exist, danger should be measured at the expense of other areas where fires seldom occur, if a sacrifice is necessary. In some areas fires are almost entirely confined to valleys; consequently there is little need for measuring danger on adjacent high mountains. The danger station needs, therefore, must be determined separately for each section of the country.

#### Site

The exact spot for setting up a fire danger station should be selected with extreme care because actually the fuel moisture and wind measured will be typical of only the immediate surroundings. If the site is typical of the problem areas, however, the danger ratings obtained can be used with certainty that they represent conditions of major importance.

All stations following the previously described systems of danger rating should be located under natural forest conditions if satisfactory results are to be obtained. The surrounding vegetation and ground cover should be as nearly typical of the general area as can be found, especially in regard to species, density, and size. Exposures in sedgegrass fields or similar completely exposed areas should be avoided. While some fires start in these places, most of the control job and much of the spread are in adjacent

woods. The following points may serve as a guide to danger station location in this respect:

1. In the eastern mountain regions locate stations on 10 to 20 percent slopes if possible. Level ground to 10 percent slopes and 20 to 30 percent slopes are next best.

2. There is little to choose between aspects from south around to west, but south and southwest are preferable to west. Southeast and northwest slopes are permissible, but not recommended. East, northeast, and north aspects should be avoided.

3. In all types it should be remembered that cover density and relation of topography to prevailing winds in the locality are more important than slope and aspect.

4. Stations should be located so as to receive winds from every direction or at least the prevailing daytime direction.

#### Instrument Exposure

In hardwood stands the exact spot to place the wood sticks is easily determined after a representative site has been chosen, because the natural fuels are essentially fully exposed to the sun during the leafless season and completely shaded during the summer. Comparability between danger stations in a hardwood region, quite an important consideration, is easily obtained by placing the sticks where they will get such sun-shade conditions.

In coniferous stands the sticks should be located so as to get partial sunlight and shade throughout the day, in a proportion approximate to that received by natural litter. If the stand is typical in density of the type to be sampled, then a suitable stick location can be chosen by study of probable sun and shade patterns at each of several possible spots. On some areas, such as cutover land or blowdown, the sticks must be exposed to nearly full sunlight to be typical of natural fuel.

Anemometers should be supported so that the cups are at the standard 8-foot level. This exact height above ground is not imperative but a departure of more than half a foot in either direction should be avoided.

Instruments should not be placed so as to be sheltered by structures or other barriers to wind movement, except that they should be exposed under typical forest conditions. Anemometers should not be nearer than 10 feet to trees 10 inches or larger in

diameter.

Sometimes it is advisable to set up the anemometer in a spot removed from the danger station site in order to measure wind at a better exposure. By wiring the instrument back to the weighing shelter and adding sufficient batteries, wind readings may be taken without the necessity of the observer walking a considerable distance to the chosen spot.

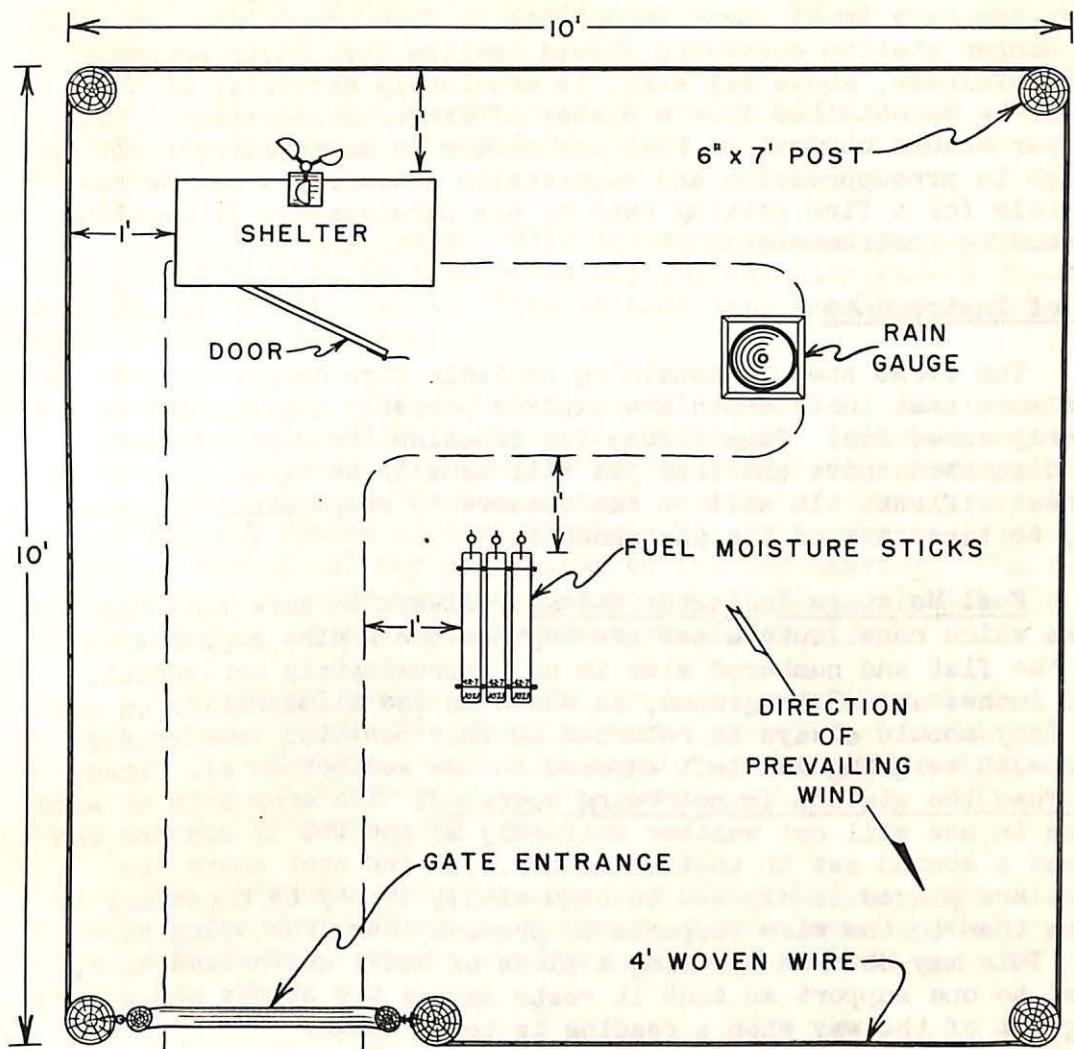
The rain gauge should be in an opening in the forest or a nearby clearing where a 45-degree angle from the top of the gauge clears the nearest obstacle. Sometimes such an exposure is not possible but it should be selected when available. Next best is to place the gauge directly under the center of the largest crown opening.

#### General Arrangement of Danger Station Equipment

The arrangement of danger station equipment should be similar to that shown in the accompanying diagram. The fuel moisture indicator sticks are supported on wire brackets 8 inches above the ground in such position as not to be shaded by the shelter. The rain gauge may be placed nearby if a spot that meets requirements can be found. Ordinarily the rain gauge will have to be placed in an opening in the vicinity of the danger station. The weighing shelter should be placed so that the door opens in the lee of prevailing winds.

It is highly advisable to construct a wire fence around the instrument exposure. This not only adds to its appearance but reduces the chances of stick breakage by domestic stock or wild game and meddling by passers-by. Ordinarily the equipment can be enclosed in a fence 12 feet square or less. Sometimes a smaller wire fence around only the wood sticks serves the purpose. It should not be made of heavy rails that will shelter the sticks from sun, wind, and rain. If a danger station is fenced, vegetation should not be cleared from the enclosure. To avoid trampling of lesser vegetation and eventual obliteration of litter, paths should be constructed within the fenced area and observers should confine their routine movements to them. If a station is on a hillside where there is danger from washing by heavy rains, a ditch should be dug across the upper side of the enclosure to carry excess water away.

## MODIFIED GROUND PLAN FOR DANGER STATION



### Instructions for Observers at Fire Danger Stations

The utility of fire danger ratings depends, of course, upon the reliability of the records that go into the ratings. Naturally, accuracy is of first importance in fire danger measurement. Fire danger station observers should realize that their accuracy and carefulness, above all else, is absolutely essential if the most is to be obtained from a system of danger measurement. Each observer should understand that the errors he makes carry right on through to presuppression and suppression action. He can be responsible for a fire getting away by his carelessness in handling and reading instruments.

#### Care of Instruments

The first step in obtaining reliable fire danger records is to be sure that instruments are exposed properly and thereafter are properly cared for. Suggestions for choosing the best exposure were discussed above and this job will usually be taken care of by a forest officer. It will be the observer's responsibility, however, to take care of the instruments.

Fuel Moisture Indicator Sticks. Always be sure that the 3 sticks which constitute a set are kept on the 2 wire supports so that the flat and numbered side is up, approximately horizontal, and 8 inches above the ground, as shown in the illustration on page 22. They should always be returned to this position immediately after each weighing and left exposed to the weather at all times, even when the station is not being operated. The many sets of wood sticks in use will not weather uniformly if one set is exposed one way and a second set in another manner. If the spot where the sticks are placed is exposed to high winds, it may be necessary to secure them to the wire supports to prevent them from being blown off. This may be done by using a piece of heavy galvanized wire, hinged to one support so that it rests across the sticks and can be swung out of the way when a reading is to be taken.

The fuel moisture indicator sticks will give a reliable indication of the changes in fuel moisture content if they are handled carefully and the following points observed:

1. Never handle the sticks with sweaty, dirty or greasy hands. Excessive handling clogs the pores of the wood and it will not respond readily to atmospheric changes.
2. Handle the sticks carefully to avoid splitting, chipping, or marring.

3. If dust or dirt of any kind should get on the sticks, brush it off lightly with a clean, dry cloth or soft brush.

4. Keep the ground under and around the wire supports covered with leaves so that hard rains will not splash mud on the sticks.

5. Notify the ranger or other responsible forest officer if anything happens to the set of sticks so that immediate replacements may be made.

Fuel Moisture Scale. This instrument requires no special care except that it be handled as any delicate instrument should be. Do not oil the pivot. This is made from hard nickel silver and requires no lubricant.

Anemometer. The anemometer should be oiled once a month with a high-grade, light instrument lubricant. While an animal oil such as porpoise or whale oil is the very best, good typewriter oil is satisfactory. The buzzer type anemometers should be oiled at the top and bottom of the spindle. When the cups are removed, a drop or two of oil may be applied to the top bearing. The face plate must be removed to reach the bottom bearing on which the spindle rests. Do not use an excessive amount of oil.

Anemometers should be taken down and carefully cleaned once a year. Instructions for cleaning each type of instrument are given in the appendix. Observers should not take these instruments apart for cleaning unless they have been specifically instructed to do so by their superior officer.

The observer should be sure that the spindle of the instrument is plumb at all times. Otherwise, uneven wearing will result, readings will be in error, and the instrument will have to be replaced.

Rain Gauge. The top of the rain gauge should be kept level. The funnel must be handled carefully lest it become bent. Check this occasionally to see if the funnel is round; that is, not bent out of shape. All debris, such as leaves, needles, and insects, should be cleaned out of the gauge regularly.

#### Reading of Instruments

Moisture Content Determination. Before stick moisture can be determined the fuel moisture scale must be checked to see that it is level or that its "zero setting" is correct. To do this, first set the sliding adjustment on the balance arm at 100 and

hang the 100-gram test weight on the hook at the left end of the beam. When the beam stops swinging, tap the pivot with the finger to settle the pointer to the correct mark. It may lag a little owing to a slight amount of friction at the pivot point. If the pointer does not read zero, loosen the wing nut on the right and move the slotted scale support until zero is indicated. After the wing nut is tightened, tap the pivot with the finger again. If the pointer still does not read zero repeat the operation until the zero point is reached. The scale should thus be checked and leveled once each week.

After the scale has been leveled the sliding adjustment is returned to a position that indicates the oven-dry weight of the set of sticks. The correct weight is shown on a card that accompanies each set. Because wood sticks weather and lose weight, a successively lower setting of the sliding adjustment is required every 2 weeks. A sample weathering card is reproduced below.

IMPORTANT

Sticks must first be exposed between Aug. 25 & Sep. 6

Set the slider on the balance arm of your fuel moisture scale as follows for wood sticks # 41-270

|                     |                 |        |              |       |
|---------------------|-----------------|--------|--------------|-------|
| When first exposed, | <u>Sept. 1</u>  | (date) | <u>104.2</u> | grams |
| At 2 weeks,         | <u>Sept. 15</u> | (date) | <u>103.8</u> | grams |
| At 4 weeks,         | <u>Sept. 29</u> | (date) | <u>103.5</u> | grams |
| At 6 weeks,         | <u>Oct. 13</u>  | (date) | <u>103.3</u> | grams |
| At 8 weeks,         | <u>Oct. 27</u>  | (date) | <u>103.1</u> | grams |
| At 10 weeks,        | <u>Nov. 10</u>  | (date) | <u>103.0</u> | grams |
| At 12 weeks,        | <u>Nov. 24</u>  | (date) | <u>102.9</u> | grams |
| At 16 weeks,        | <u>Dec. 8</u>   | (date) | <u>102.8</u> | grams |
| At 20 weeks,        | <u>Jan. 19</u>  | (date) | <u>102.7</u> | grams |
| At 24 weeks,        | <u>Feb. 16</u>  | (date) | <u>102.6</u> | grams |

(POST THIS CARD IN SHELTER BENEATH SCALE)

The dates when wood sticks should first be exposed, their serial number, and the "grams" column of weights are filled in before the sticks are mailed. The observer must fill in the "date" column as indicated, beginning with the date when the sticks are first exposed. A calendar for this purpose will be of assistance and will eliminate any chances for errors. Notice that the card should be posted in the scale shelter immediately beneath the fuel moisture scales.

When the sliding adjustment has been set correctly, the 3 wood sticks are hung together on the scale hook by means of the small wire loop fastened to each stick. The picture on page 29. illustrates the correct manner in which to suspend the sticks on the hook. After the beam stops swinging, tap the pivot before reading the scale. This is important and its omission has caused frequent errors in the past. The pointer indicates the average moisture content of the 3 sticks. This should be read to the nearest 1/10 of one percent and recorded on the form for that purpose.

Whenever snow has fallen upon the wood sticks the observer should record "S" (for "snow") but not weigh the sticks. The snow should be allowed to remain on them until it melts at which time weighings may be resumed in the usual fashion.

Wind Measurement. Wind velocity may be determined at the stations equipped with a 1/60-mile transmitter or buzzer type anemometer by counting the number of signals during a one-minute period. A 2 or 3-minute count is recommended, however, because it is much more accurate, especially on gusty days.

To take a reading, close the switch in the anemometer circuit and wait for a buzz or signal. Begin timing with a watch immediately after the buzz stops but do not count that signal. Begin counting at the next buzz and tally the total during a 2 or 3-minute period. Wind velocity in miles per hour is then obtained by dividing the total number of buzzes by the number of minutes and adding the amount indicated on the wind correction chart. For example, 10 buzzes in 2 minutes equals 5, plus a correction of one as shown by the wind correction chart, equals 6 miles per hour. Wind velocity should always be recorded to the nearest 1/2 mile. For example, 11 buzzes in 2 minutes equals  $5\frac{1}{2}$  plus the correction, or  $6\frac{1}{2}$  miles per hour. Most companies furnish wind correction charts with their instruments. Copies are reproduced for the Stewart, Friez, and Chisholm types in the appendix.

An average of 2 separate readings a few minutes apart is always desirable on days when the wind is unsteady and variable.

If a station is equipped with the more expensive Weather Bureau type anemometer with a dial, average velocity is obtained by subtracting one dial reading from a second, later one. To get miles per hour, this difference, which represents the total wind movement for the period, must then be divided by the number of hours between the 2 readings. For example, at 1 p.m. a reading of 621.5 was observed and at 5 p.m., 640.7. The difference is 19.2 miles, which, divided by 4 hours equals 4.8 miles per hour average

velocity. This value should then be corrected by means of the table reproduced in the appendix.

Precipitation. Rain is measured with a graduated ruler or measuring stick by inserting the stick slowly and carefully (to avoid splashing) into the small measuring tube of the rain gauge which holds the water, before the funnel top has been removed. The depth of the water is then read by withdrawing the stick and noting the position of the water line with respect to the nearest graduation. Sticks are graduated in inches of rain and tenths and hundredths. An inch of water equals only 1/10 inch of rain because the funnel top of the gauge concentrates ten times the actual rainfall into the measuring tube. The amount of rain is recorded in decimals like dollars and cents; 1.25 equals one inch and 25 hundredths.

The rain measuring stick will become dirty and greasy in time and the water line will not stand out sharply. When this occurs, a new stick should be requested. Sticks will last longer if they are not wiped or handled with dirty or greasy hands. Do not use a homemade stick or ruler if the standard measuring stick is broken but order a new one.

The standard Weather Bureau gauge holds 2 inches of rain in the measuring tube and will seldom run over between readings. The Forest Service type, however, holds only 1/2 inch in the measuring tube before it runs over into the larger container. When this happens, measure the amount of rain in the small measuring tube, empty it, pour the remaining water from the outside can into the tube, measure it, and repeat the process until all of the rain has been measured and totaled.

In regions where snowfall is likely at intervals through a winter fire season, the funnel top of the rain gauge should be left off to facilitate the catch of snow. Always melt snow and ice in the rain gauge and pour the water into the small inner tube before measuring in the regular way.

#### Recording Observations

Observations will be recorded on Form 14, Fire Danger Daily Record, (see accompanying sample) at most stations but at cooperative Weather Bureau stations it is satisfactory to use Form 1009-E, standard form furnished these few stations that supply weather measurements. Some national forests have modified Form 14 somewhat to fit their requirements and observers at these stations should, of course, use the standard for their unit.

FIRE DANGER DAILY RECORD

Station \_\_\_\_\_ Forest \_\_\_\_\_ District \_\_\_\_\_

Month \_\_\_\_\_ Year \_\_\_\_\_ Observer \_\_\_\_\_

| Day of month | C.S.T.        |       |        | 7 a.m.                  |                          | 1 p.m.                  |                          |                         | 4 p.m.                   |                         |                          | No. days<br>since<br>last<br>rain of |  | Class of fire danger |  |  |  |  |
|--------------|---------------|-------|--------|-------------------------|--------------------------|-------------------------|--------------------------|-------------------------|--------------------------|-------------------------|--------------------------|--------------------------------------|--|----------------------|--|--|--|--|
|              | E.S.T.        |       |        | 8 a.m.                  |                          | 2 p.m.                  |                          |                         | 5 p.m.                   |                         |                          |                                      |  |                      |  |  |  |  |
|              | Precipitation |       | Amount | Wind velocity<br>m.p.h. | Fuel moisture<br>percent |                                      |  |                      |  |  |  |  |
| 1            |               | Began |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 2            |               | Ended |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 3            |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 4            |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 5            |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 6            |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 7            |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 8            |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 9            |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 10           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 11           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 12           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 13           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 14           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 15           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 16           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 17           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 18           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 19           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 20           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 21           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 22           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 23           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 24           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 25           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 26           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 27           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 28           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 29           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 30           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |
| 31           |               |       |        |                         |                          |                         |                          |                         |                          |                         |                          |                                      |  |                      |  |  |  |  |

Three observations are recorded each day, at 7 a.m., 1 p.m., and 4 p.m., Central Standard Time, or 8 a.m., 2 p.m., and 5 p.m., Eastern Standard Time. While these hours are recommended, there may be reasons for changing them in some localities because of pressure of other work or similar reason. The form will accommodate one month's record. Headings should be completely filled in.

Precipitation. Precipitation is measured morning and evening. It is important to show time of beginning and ending of rainfall, in hours and minutes, and to put down the letters "a.m." or "p.m." as the case may be. For example, 11:10 a.m. to 1:15 p.m. If it is raining at the time of measurement, put "cont." (for "continued") in the column "ended." Then at the next measurement show the time the rain ended. As an illustration, suppose it began raining at 6 a.m. and rained until 11 a.m. The record of time of precipitation would be:

8 a.m. reading (began 6 a.m.  
(ended (cont.)

5 p.m. reading (began -----  
(ended 11 a.m.

If rain or snow occurs during the night and the time of beginning and ending is unknown, put "DN" in these spaces to signify "during night." If intermittent showers occur, write "showers" and show the time of ending of the final shower.

If the amount of rain is less than 0.01 inch and is too small to measure, enter "Trace" in the amount column. If just a few drops of rain fall, they should be shown as a trace.

Wind. Average winds obtained from buzzer counts are entered in the proper columns on Form 14 three times each day. If a dial type anemometer is used, the dial readings may be entered under "wind velocity" and the average miles per hour entered in the right margin.

Fuel Moisture. Three daily readings of wood stick moisture are entered as shown. At cooperative Weather Bureau stations where Form 1009-E is used, the readings should be entered in the spaces provided.

Ordinarily the observer will not need to fill in the "days since rain" column or be required to determine class of fire danger unless he serves as fire dispatcher as well. For example, a lookout man who operates a danger station and functions as a dispatcher for his territory would desire to fill out completely these last 3 columns on Form 14. In such cases, the observer is referred to

"Instructions for dispatchers" given below.

Number of Forms. The number of copies of Form 14 that should be kept is left to the discretion of the forest officer responsible for the operation of the fire danger station. Ordinarily, at least 2 copies are desired. The Weather Bureau usually asks that Form 1009-E be made out in triplicate.

#### Instructions for Dispatchers

Ordinarily it will be the dispatcher's or similar individual's job to assemble complete fire danger records daily from each danger station on his district, summarize them, and keep an up-to-date record of the fire danger class for the current day and that predicted for the next. Only in this way can the necessary organization changes be made quickly and effectively.

The dispatcher should constantly keep in mind that fire danger may vary considerably from one part of his district to another, from south slope to north slope, from valley to mountain top. Usually the number of stations is inadequate to sample every condition that exists over a large area. It is emphasized, therefore, that dispatchers should use judgment when basing presuppression or suppression action on danger ratings. Until more is learned about where to locate stations and how to modify readings at key stations, the dispatcher's experienced judgment is the only guide available.

#### Summary of Danger Records

Dispatchers will find the Fire Danger Summary, Form 15, a convenience in assembling data from 2 or more danger stations and in rating fire danger. This is a daily form and space is provided for the entry of measurements made at 5 stations, as will be noted from the sample copy accompanying these instructions.

At the close of each day (or at intervals during the day if desired) the dispatcher should communicate with the fire danger observers and obtain the complete records taken at the 3 periods of observation. These are summarized in the lower portion of the form and a rating of fire danger class for today and tomorrow at each station and for the district as a whole is obtained. District danger ratings should be made from averages of moisture, wind, and rain at the several stations and not be obtained by averaging the danger classes for each station.

Precipitation. Most of the lines in the summary are self-explanatory. When tallying "days since last rain", only one of the

DAILY FIRE DANGER SUMMARY

Forest \_\_\_\_\_ Ranger District \_\_\_\_\_ Date \_\_\_\_\_

| Time of observation                 | Factor measured  | Station               |  |  |  |  | Space for remarks & averaging of danger class |        |       |
|-------------------------------------|--|-----------------------|--|--|--|--|---|--------|-------|
|                                     |  |                       |  |  |  |  |   |        |       |
| CST EST<br>7 am                     | Precipitation  | Began                 |  |  |  |  |   |        |       |
|                                     |  | Ended                 |  |  |  |  |   |        |       |
|                                     |  | Amount                |  |  |  |  |   |        |       |
|                                     | 8 am   | Wind velocity, m.p.h. |  |  |  |  |   |        |       |
| Fuel moisture percent               |  |                       |  |  |  |  |   |        |       |
| Fire danger class                   |  |                       |  |  |  |  |   |        |       |
| 1 pm                                | Wind velocity, m.p.h.                                      |                       |  |  |  |  |   |        |       |
|                                     |  |                       |  |  |  |  |   |        |       |
|                                     |  |                       |  |  |  |  |   |        |       |
|                                     | 2 pm   | Fuel moisture percent |  |  |  |  |   |        |       |
| Fire danger class                   |  |                       |  |  |  |  |   |        |       |
|                                     |  |                       |  |  |  |  |   |        |       |
| 4 pm                                | Precipitation  | began                 |  |  |  |  |   |        |       |
|                                     |  | ended                 |  |  |  |  |   |        |       |
|                                     |  | amount                |  |  |  |  |   |        |       |
|                                     | 5 pm   | Wind velocity, m.p.h. |  |  |  |  |   |        |       |
| Fuel moisture percent               |  |                       |  |  |  |  |   |        |       |
| Fire danger class                   |  |                       |  |  |  |  |   |        |       |
| <u>DISTRICT AVERAGE FOR THE DAY</u> |  |                       |  |  |  |  |   |        |       |
| S                                   | Amount of last rain, average for district                  |                       |  |  |  |  |   |        |       |
| U                                   | Number days since last rain                                |                       |  |  |  |  | 0.25" to 0.50" for district as a whole        |        |       |
| M                                   |  |                       |  |  |  |  | 0.51" or more for district as a whole         |        |       |
| M                                   | Average afternoon wind velocity for all stations           |                       |  |  |  |  |   |        |       |
| A                                   | Average of lowest fuel moisture readings from all stations |                       |  |  |  |  |   |        |       |
| R                                   | Average condition of vegetation for district               |                       |  |  |  |  | Green   | Trans. | Cured |
| Y                                   | Average visibility distance for district                   |                       |  |  |  |  |   |        |       |
|                                     | Class of organization on duty                              |                       |  |  |  |  |   |        |       |
|                                     | Fire danger class for district                             |                       |  |  |  |  | Today   |        |       |
|                                     |  |                       |  |  |  |  | Predicted for tomorrow                        |        |       |

2 lines is used, depending upon whether the last rain totaled 0.25 inch to 0.50 inch or 0.51 inch or more. All rains less than 0.25 inch are disregarded when tallying days since rain. If several rains occur that are not separated by drying weather, they should be lumped together and called one rain for purposes of figuring days since rain. ("Drying weather" occurs whenever the wood sticks drop below 20 percent moisture content.) For example, suppose it rained 0.38 inch yesterday afternoon and 0.20 inch this morning, stopping at 11 a.m., when it cleared and the sun came out. Since no pronounced drying could have occurred during the night between the 2 rains, for all practical purposes the amount of the last rain would be 0.58 inch. If "today" had remained cloudy and foggy and the fuel moisture did not drop below 20 percent, zero days since rain would be shown for today. When intermittent showers extend over a period of a day or more with the fuel moisture remaining above 20 percent, they should be called one rain.

It is emphasized that all distinctly separate small rains and showers that total less than 0.25 inch are disregarded in summarizing days since rain.

If snow covers the ground at the time of observation, put a letter "S" in the line "days since last rain." Fire danger should always be rated class 1 when snow covers the ground fuels. When measurements are to be commenced in the spring at a station where snow has recently melted, the number of "days since rain" should be counted from the day the snow became patchy at the station site rather than the last day of snowfall or of rain. Of course, the melting snow is as effective in wetting fuels as an equivalent amount of rain. (Ten inches of newly fallen snow equals approximately one inch of rain.) At part-time stations being opened for fire season operation, observers or dispatchers should determine from records at nearby full-time stations the correct number of days since rain for the starting date.

Wind. Average afternoon wind velocity is recorded in the summary. If a station reports in miles per hour, the 2 afternoon readings are averaged. If a station is equipped with a standard Weather Bureau anemometer and reports dial readings, average afternoon velocity is determined by subtracting the smaller from the larger value and dividing by the number of hours between the 2 readings. The morning wind reading is not used in the summary but dispatchers will find that this early observation often will indicate to them conditions that may develop into a windy day.

Fuel Moisture. The lowest fuel moisture for the day is shown in the summary. Occasionally the early morning fuel moisture will be the lowest because of late morning or afternoon

showers. In such a case, these low readings will be used for the summary since the higher fire organization was justified in the morning. Most often the first afternoon reading will register lowest moisture.

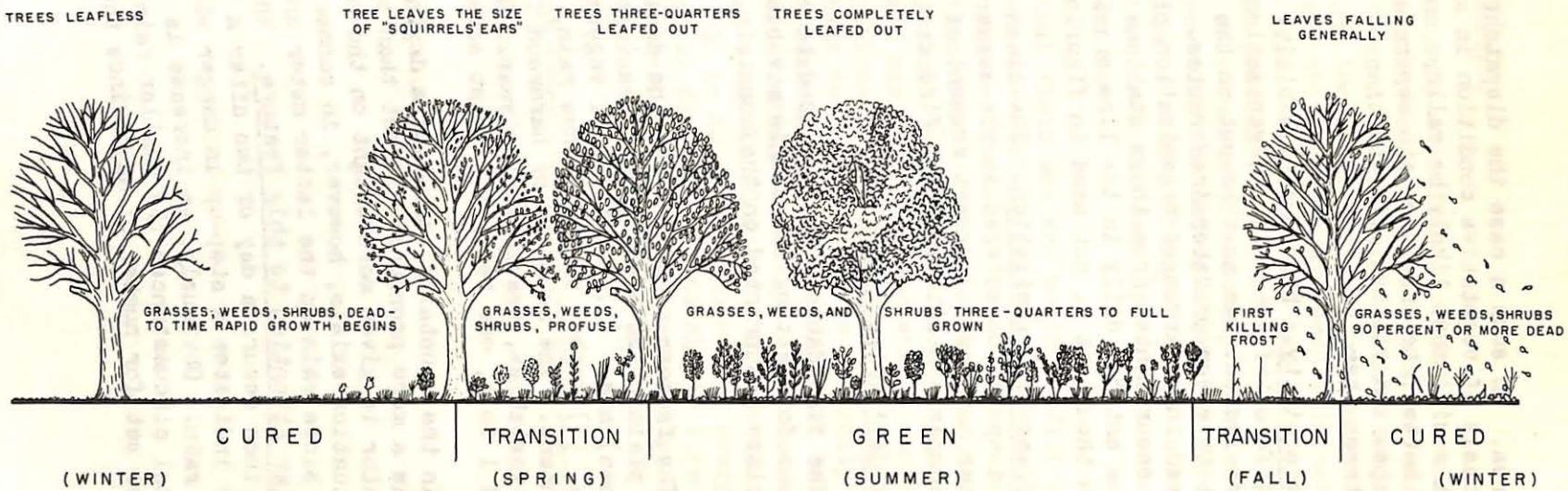
Condition of Vegetation. Since there is no exact and practical way to measure condition of vegetation, certain indices combined with the best judgment of the field men are relied upon to determine the status of this factor. It will usually be the dispatcher's responsibility to procure this information from the best sources and enter it currently on Form 15 by checking one of the 3 possibilities, green, transition, or cured, shown in the fifth line of the summary.

In all cases the condition of lesser vegetation will be classified; that is, grasses, weeds, and shrubs as distinct from trees. The classification "green" is used from the time when grasses, weeds, and shrubs become one-half to three-quarters grown, continuing through the summer until they are cured by fall frosts. These changes usually coincide with the period when trees become more than three-quarters leafed out until the first fall frost causes noticeable and widespread coloration. The spring transition period extends from the time grasses and weeds begin to spring up in profusion until they are three-quarters grown. This period usually coincides with the time the tree leaves reach the "size of squirrels' ears" until trees are three-quarters leafed out. The begins when the first fall frost causes curing of the lesser vegetation, and lasts until it is at least 90 percent cured. Tree leaves have usually begun to fall quite generally throughout the fall transition, shorter and more abrupt than the spring period, forest by the end of the autumn transition. The classification "cured" is easy to determine and is used for the remainder of the year. This period extends from that time in the fall when lesser vegetation is 90 percent cured, into the spring when grasses and weeds begin the period of rapid growth and tree leaves are the "size of squirrels' ears."

There must be exceptions to the general rules for determining condition of vegetation. For example, on areas where huckleberry brush predominates, curing may begin much earlier than elsewhere. In sedgegrass fields where little else grows, the period "green" may first occur about mid-July or early August. However, if care is used, the classification of vegetation in general can be made with little chance for error. The chart shown on page 45 may be of some assistance in this.

The greatest difficulty comes in mountain areas where elevation differences produce all 3 conditions simultaneously on a

## CLASSIFICATION OF CONDITION OF LESSER VEGETATION



small area. In such a case the dispatcher should rate his district on the basis of vegetative condition in areas where risk is greatest. This will most likely be valleys and lower slopes in the East. Or even better, he should obtain separate danger ratings for mountain slopes and valleys, if condition of vegetation differs materially between them.

Visibility. When poor visibility accompanies high fire danger a different fire control organization becomes necessary. Perhaps more lookout men must be put on the job or special patrols be sent out to cover predetermined routes. Visibility distance is considered in prearranged organization plans. For this reason visibility measurements, from those stations equipped to measure it, should be entered daily in the line provided in the summary of Form 15, even though it is not used in figuring danger class.

Class of Organization. The class of fire control organization on duty may be entered in the summary if desired so that the dispatcher may have a current account of actual action taken each day in comparison with measured fire danger.

#### Rating Today's Fire Danger

The fire danger meter is used to rate today's danger. Instructions for setting the single movable slide and reading the danger class are printed on the mountain and coastal plain danger meters.

The factors considered on the device applicable to the coastal plain or southern pine types (exclusive of longleaf-slash pine types) are: (1) condition of vegetation, (2) average wind velocity, (3) number of days since rain, and (4) lowest fuel moisture content. The mountain or hardwood type meter adds to this list of variables, season of the year. Both rate danger on a scale of 1 to 5, one being the least severe class.

In the mountains, cumulative drying, indicated by days since rain, has a more pronounced effect than on the coastal plain, hence this factor is given more weight on the mountain meter. An anomalous situation exists, however, in connection with classification of days since rain on the latter meter and dispatchers should pay particular attention to this feature. Whenever a rain of 0.25 inch to 0.50 inch occurs a day or two after a larger rain, the meter actually indicates a step-up in danger with the occurrence of the smaller rain. Obviously, an increase is incorrect; hence, in these occasional circumstances the smaller rain should be disregarded and the meter set for number of days since the first and larger rain.

### Rating Tomorrow's Fire Danger

The danger meters used heretofore provided a mechanical means for forecasting tomorrow's danger from existing and predicted conditions. While this system worked with a satisfactory degree of accuracy in some localities, it did not do so universally in the mountains and this feature has been eliminated from the new mountain meter. However, experience has shown that a dispatcher, with a little practice, can predict fire danger 24 hours in advance with a fair degree of accuracy if he estimates fuel moisture for tomorrow with the aid of a weather forecast and has available a prediction of wind. This procedure is recommended as a useful system wherever a man develops sufficient skill to make his predictions accurate.

It is important that field men who would predict fire danger, and also those who use weather forecasts, understand the terminology used by the Weather Bureau in fire-weather forecasts. Much of the so-called "inaccuracy" of predictions in the past has really been the fault of field men who have misinterpreted forecasts. The Weather Bureau has issued a booklet<sup>6/</sup> in which every term used in their predictions is defined. Many men who use forecasts do not understand that such words as "slightly" and "somewhat" have specific meanings in terms of degrees temperature, miles per hour of wind, and percent humidity. Many do not realize that "possibly" indicates a "40 to 60 percent chance of occurrence" and "probably" a "50 to 80 percent chance." Every man who attempts to use fire-weather forecasts as an aid in fire control should have a complete understanding of the terminology used. Booklets can be obtained free of charge from the Weather Bureau, Asheville, North Carolina.

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6/Fire Weather Forecast Terminology, U. S. Dept. Agr.,  
Weather Bureau. 1940.

## REFERENCES FOR FIRE DANGER STATION OBSERVERS AND DISPATCHERS

The following partial list of references is suggested for those who wish to read further on fire danger measurement and related subjects:

1. BICKFORD, C. A. AND BRUCE, DAVID  
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5. GISBORNE, H. T.  
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6. \_\_\_\_\_  
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1939. Forest Pyrology. Scientific Mo. 49:21-30, illus.
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1935. Influence of weather factors on moisture content of light fuels in forests of the northern Rocky Mountains. Jour. Agr. Res. 51:885-906, illus.
10. MATTHEWS, DONALD N.  
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12. SHOW, S. B. AND KOTOK, E. I.  
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13. SIMSON, A. G.  
1930. Relative humidity and short-period fluctuations in  
the moisture content of certain forest fuels.  
U. S. Monthly Weather Rev. 58:373-374.
14. STICKEL, P. W.  
1931. The measurement and interpretation of forest fire-  
weather in the western Adirondacks. N. Y. State  
College of Forestry, Syracuse University, Tech.  
Pub. 34, 115 pp., illus.

## APPENDIX

The following pages are reproductions of special abbreviated instructions for observers which may be of additional help to fire danger station operators. For example, the summary of points to watch in opening and closing a station should serve as a useful check list. Descriptions of the methods of dismantling and cleaning anemometers are given, also the wind correction charts for use with the latest models of anemometers. Copies of all instructions contained in this section may be obtained from Director, Appalachian Forest Experiment Station, Asheville, North Carolina.

Wind Correction Chart for Chisholm Anemometers

| Contacts counted                 | : 1936-1938<br>models          | : 1939 model            |                         |
|----------------------------------|--------------------------------|-------------------------|-------------------------|
| Moderate winds<br>2-minute count | Strong winds<br>1-minute count | Wind velocity<br>m.p.h. | Wind velocity<br>m.p.h. |
| 2                                |                                | 2                       | 2                       |
| 4                                |                                | 3                       | 3                       |
| 6                                |                                | 4                       | 4                       |
| 8                                |                                | 5                       | 5                       |
| 10                               |                                | 6                       | 6                       |
| 12                               |                                | 7                       | 7                       |
| 15                               |                                | 8 $\frac{1}{2}$         | 8                       |
| 17                               |                                | 9 $\frac{1}{2}$         | 9                       |
| 19                               |                                | 11                      | 10                      |
| 24                               |                                | 14                      | 12                      |
| 28                               |                                | 15                      | 14                      |
| 32                               |                                | 18                      | 16                      |
| 36                               |                                | 20                      | 18                      |
| 40                               |                                | 22                      | 20                      |
| 45                               |                                | 24                      | 22                      |
|                                  | 25                             | 27                      | 24                      |
|                                  | 27                             | 29                      | 26                      |
|                                  | 29                             | 31                      | 28                      |
|                                  | 31                             | 33                      | 30                      |
|                                  | 34                             | 36                      | 32                      |
|                                  | 36                             | 38                      | 34                      |
|                                  | 38                             | 40                      | 36                      |
|                                  | 40                             | 42                      | 38                      |
|                                  | 42                             | 44                      | 40                      |
|                                  | 44                             | 46                      | 42                      |

Wind Correction for Stewart Anemometer

| <u>Contacts per minute</u> | <u>To get true velocity</u> |
|----------------------------|-----------------------------|
| 1 to 9                     | Add 1 mile                  |
| 10 to 39                   | No correction               |
| 40 to 49                   | Subtract 1 mile             |
| 50 to 59                   | Subtract 2 miles            |
| 60 to 69                   | Subtract 3 miles            |

### Wind Correction for Friez Anemometers

The Friez 1/60-mile buzzer type anemometer has a one mile per hour correction for winds from 0 to 37 m.p.h. and a one-half mile correction for winds in excess of 37 m.p.h.

#### Contacts per minute      To get true velocity

|          |                        |
|----------|------------------------|
| 0 to 37  | Add 1 mile             |
| 38 to 50 | Add $\frac{1}{2}$ mile |

Three- and four-cup Friez anemometers, Weather Bureau pattern, require the following corrections:

| Velocity indicated |                  | :                                  |                      |
|--------------------|------------------|------------------------------------|----------------------|
| :                  |                  | :                                  |                      |
| :                  |                  | :                                  |                      |
| 3-cup anemometer   | 4-cup anemometer | 4-cup anemometer with beaded cups: | Correction in m.p.h. |
| 0 to 16            | 0 to 8           | 0 to 5                             | +1                   |
| 17 to 26           | 9 to 12          | 6 to 13                            | 0                    |
| 27 to 35           | 13 to 16         | 14 to 20                           | -1                   |
| 36 to 44           | 17 to 20         | 21 to 27                           | -2                   |
| 45 to 52           | 21 to 24         | 28 to 34                           | -3                   |
|                    | 25 to 28         | 35 to 41                           | -4                   |
|                    | 29 to 32         | 42 to 48                           | -5                   |
|                    | 33 to 36         | 49 to 55                           | -6                   |
|                    | 37 to 39         |                                    | -7                   |
|                    | 40 to 43         |                                    | -8                   |
|                    | 44 to 47         |                                    | -9                   |
|                    | 48 to 51         |                                    | -10                  |

INSTRUCTIONS FOR FIRE DANGER STATION OBSERVERS  
(Post this sheet in weighing shelter)

Note: Before operating this station, each observer should read pages 34 to 41 of Technical Note 50, Appalachian Forest Experiment Station, "The Measurement of Forest Fire Danger in the Eastern United States and Its Application in Fire Prevention and Control", by G. M. Jemison. Request copy from the ranger if one is not available.

GENERAL:

Accuracy of all readings is essential. Never guess at a value. Write reading down as soon as taken.

FUEL MOISTURE MEASUREMENT:

1. Scales should read 0.0 when the test weight is on the hook and the counterbalance slide is set at 100.0. Check this weekly. If not reading 0.0, correct by loosening wing nuts and tilting scale up or down.
2. Set counterbalance slide at point designated on the weathering correction card on dates given. Weigh all 3 sticks together.
3. Do not read the scale until the pointer has become still--always tap the pivot block with forefinger or a pencil rubber just before reading.
4. Handle wood sticks with care--never with sweaty, dirty, or greasy hands--avoid splitting, chipping, or marring--brush off lightly with clean dry cloth all dirt spattered on sticks by rain.
5. If fuel moisture scales become sluggish, place a few drops of kerosene oil on the pivots--never use machine oil.
6. Wood sticks should be used (actually exposed to the weather) 6 months (7 or 8 months in New England). New ones will be sent about 2 weeks before they are needed.

WIND MEASUREMENT:

1. The anemometer should be in the exact vertical position, the spindle plumb.
2. Always use watch to determine the time interval for the reading. Start timing after the first signal--do not count this signal but all succeeding signals during the time interval. If a correction factor is needed, make sure it is used to convert number of signals to correct miles of wind per hour.
3. Oil anemometer once a month--use only 2 or 3 drops of a very light oil, such as typewriter oil or even one thinner.

RAIN MEASUREMENT:

1. Rain is measured in hundredths of inches. Record in decimals--like dollars and cents--1.25 (one inch and twenty-five hundredths).

## POINTS TO FOLLOW IN OPENING A FIRE DANGER STATION

### Scale shelter

1. Check shelter post to see if it is firm in the ground. Level post if necessary.
2. Check box to see if any leaks have appeared since station was last in use. If leaks are found they should be repaired.
3. Paint the outside of the box if it is needed. Do not paint the inside.
4. Clean out any dirt that may have accumulated in the box. Keep the box clean at all times while the station is in operation.

### Scale

1. Remove string or rubber band from balance arm.
2. Clean scales and balance weight with a cloth that has been moistened with kerosene.

### Moisture stick rack

1. Remove any large twigs or limbs that have fallen near or over the rack.
2. Measure the height of the wire rack so the moisture sticks will be 8" above the ground.
3. Be sure the bare ground or dirt is not showing under the rack or around the edges. If the soil is showing, place enough leaves or litter under the rack to cover up the bare area. This is done to prevent the soil from splashing up on the sticks during rains.

### Anemometer

1. Check the post to see if it is plumb and firm in the ground. If the anemometer is attached to the post of the scale shelter this process would be taken care of as outlined above.
2. Clean the anemometer before it is used by washing with kerosene. The method used in cleaning each type is listed as follows. These points must be strictly adhered to or damage to instruments may result.

Chisholm

- a. Take out bolt on top and remove cup assembly.
- b. Remove small bolt from the bottom of the anemometer that goes through the main shaft. Negative contact wire is also attached to this screw when the anemometer is in use.
- c. Remove electric contact unit by sliding carefully down over the end of the main shaft.
- d. Remove small screw from revolving cylinder near the top. By turning the top aluminum casting to the left with one hand and holding the cylinder with the other, the 2 pieces are separated.
- e. Now wash all parts with kerosene except the electric contact unit. Wash by plunging the parts up and down in a deep container. After washing allow excess kerosene to drain from the parts.
- f. Place about 2 drops of anemometer oil around top of the 2 roller bearings attached to the shaft. Also add about 2 drops around the cylinder gear on the inside near the top.
- g. Assemble anemometer. Place aluminum casting on top of roller bearings. Put cylinder up over shaft, by turning it to the right until the holes match in the cylinder and casting. Replace small screw. Looking in the anemometer from the bottom, move the cylinder until the small pin on the gear wheel is face up and in line with the shaft. Hold at this point. Now replace electric contact unit by sliding carefully up over the shaft into the cylinder. When holding the top of the anemometer away from you the contact points should be to the left of the main shaft. Replace small bolt through electric unit and shaft. Attach cup assembly and replace bolt. The anemometer is now ready for use.

The anemometer should be oiled once each month when it is in use. To do this, remove the bolt on top of the cup assembly and place 3 drops of oil in the hole from which the bolt was removed.

Stewart

Note: It is extremely important that the small socket in which the spindle of the instrument rests is not disturbed or removed from the housing in the cleaning process.

- a. Remove small bolt from side of cup assembly. Do not

unscrew bolt in end. Remove cup assembly by sliding it off main shaft.

- b. To remove spindle unscrew bushing shaft from cast alloy housing and slide over spindle.
- c. Now carefully remove the spindle. It may be necessary to move it from one side or the other before it will slide out. Never turn cast housing upside down. Always keep in a standing position while cleaning. If it is turned upside down the small pivot bearings will fall out.
- d. Clean the shaft bushing and the spindle with kerosene. Do not clean the grease from the gear part of the shaft.
- e. Drop some anemometer oil on each end of the spindle and inside the top of the bushing shaft.
- f. Slide spindle into place in housing and replace bushing shaft.
- g. Replace cup assembly and small bolt. The anemometer is then ready for use and no additional cleaning is needed.

When the anemometer is in use it should be oiled once each month with 2 drops of anemometer oil. The oil is placed at the top of the spindle and the bushing shaft. The cup assembly must be removed before oiling.

#### Friez

- a. Remove the tap from the top of the cup assembly and remove cups.
- b. Remove plate cover from side of anemometer.
- c. Remove bolt just above plate cover.
- d. Slide shaft out of anemometer by lifting from the top.
- e. Wash shaft and cast housing in kerosene. Use deep container and plunge up and down. Allow excess kerosene to drain and wipe remaining amount from outside of cast housing.
- f. Oil before assembling with anemometer oil. Place 2 drops on the gear part of the shaft and 2 drops on the bearing at the top of the shaft.
- g. Replace the shaft by inserting into the housing from the top. Put in bolt above plate cover. Replace plate cover. Slip on washer at top of shaft with the beveled side face down. Then replace weather shield and wind cups. Replace tap on top and the anemometer is then completely assembled.

When the anemometer is in use it should be oiled once each

month by removing the bolt above the plate cover and lifting out the shaft which will be the shaft and wind cups. Under the shelter cup drop 1 to 2 drops of anemometer oil on the bearing and 1 to 2 drops on the gear portion of the shaft.

#### U.S.W.B. - 3- and 4-cup Types

These anemometers will not be cleaned by anyone but Weather Bureau personnel. They will operate properly for some time without cleaning. It is necessary to oil them once each month by placing 2 drops of anemometer oil in the cup on top of the anemometer and 2 drops on the pivot point just under the cup back of the dial at the bottom.

3. Put light oil on the threads or shaft of the pipe to which the anemometer is attached. This will make the instrument much easier to remove when the station operation is suspended for the season.
4. Attach contact wires and batteries. Then check the anemometer to see if it is working properly. New batteries will last for 2 years if they are stored where they are dry and not too cold.

#### Rain gauge

1. See if rain gauge stand is solid in the ground. Level stand.
2. Before installing see that gauge is clean and that funnel top is not bent.
3. Place gauge in stand for use.
4. See if measuring stick is all right. If it is not usable, request new one from the ranger at once.

#### Installation of fuel moisture sticks

1. Be sure that sticks are exposed to the weather between the dates shown on the weathering card.
2. Fill out all the dates when weathering changes occur.
3. Destroy old weathering chart and place new card in scale shelter just under the bottom of the scales.
4. Balance scales and set counterbalance on the number of grams

shown at the top of the weathering table. Scales are now ready for use. The scales should be balanced once each week during the operation of the station.

5. Place moisture sticks on rack with the numbers up. Destroy any old sticks that may be at the station. Be sure sticks are 8" above the ground. New sticks should be exposed one night before weighing them for fuel moisture content.

#### Forms

1. Requirements for forms vary but most agencies request that each observer prepare 3 Forms 14 each month. By attaching 3 forms to a cardboard back and inserting carbon paper between the sheets, all the copies can be made at one time. Fill in the heading of the form, also the times when readings are taken. The original copy and first carbon are mailed to the ranger at the end of each month.

#### POINTS TO FOLLOW IN CLOSING A FIRE DANGER STATION

##### Scale and shelter

1. Tie a string or rubber band around balance arm of scale to keep it from moving.
2. Remove batteries from shelter. If they are still good store them in a place where it is dry and not too cold.
3. Close shelter and lock door.

##### Anemometer

1. Disconnect contact wires and remove anemometer from pipe support.
2. Place cover over pipe to protect the threads from rusting.
3. Store the anemometer in a dry place. It is not necessary to remove the cups or any other part of the instrument.

##### Rain gauge

1. Remove gauge from rack and store in convenient shelter.

Fuel moisture sticks

1. The fuel moisture sticks should be left exposed as it may be necessary to return to the station due to unusual weather conditions. No set of sticks should be exposed longer than 6 months (8 months in New England).

